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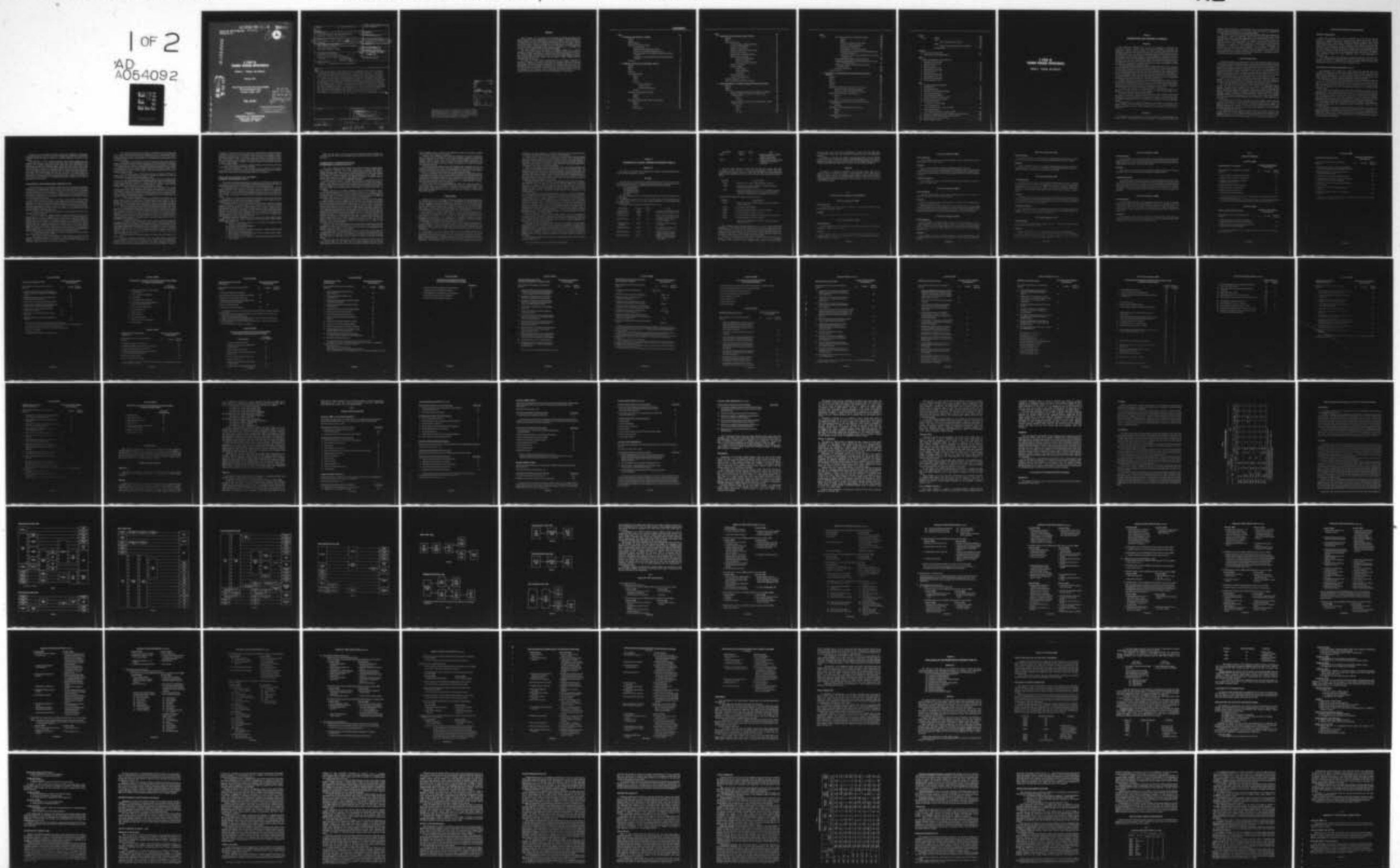

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A STUDY OF TRAINING PROGRAM IMPROVEMENTS

Volume I: Findings and Analyses

February 1972

Human Resources Research Organization (HumRRO)
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16. Abstract

An Analysis was made of the Federal Aviation Administration's Air Navigation Facilities Maintenance Training Program. The analysis included: (a) study of the overall training philosophy; (b) comparison of specific instructional activities with the kinds of instructional activities that should be carried on in order to meet the training outcomes required by maintenance concepts; (c) study of the criteria and standards governing the purchase and installation of equipment at the Academy for maintenance training purposes; (d) evaluation of the effectiveness of various teaching methods used to produce the training outcomes required in courses. Documents on the training system were collected and, where documentation was not appropriate for the collection of information, data collection instruments were constructed for the purpose of assessing the adequacy of the instructional system. Conclusions and detailed recommendations pertaining to the improvement of the training program are made.

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The contents of this report reflect the views of the Human Resources Research Organization which is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policy of the Department of Transportation. This report does not constitute a standard, specification, or regulation.

PREFACE

This is Volume I of a two-volume report describing an analysis, performed by the Human Resources Research Organization, of the Air Navigation Facilities Maintenance Training Program of the Federal Aviation Administration (FAA). This volume describes the objectives of the study, the methods that were utilized in the investigation, and the results, and presents conclusions pertaining to the improvement of the training program. The second volume recommends specific areas for improvement in the program, and describes a plan for implementing the recommended changes.

The work described was performed by HumRRO Division No. 1 (System Operations), Alexandria, Virginia, Dr. J. Daniel Lyons, Director, under the sponsorship of the Federal Aviation Administration (Contract No. DOT-FA71WA-2687). Dr. Alan G. Hundt was Principal Investigator, Mr. Robert C. Trexler was Program Manager and Senior Staff Scientist assigned to the project, and Mr. Patrick J. Butler, Research Scientist, participated fully in the study.

We thank the Federal Aviation Administration for its complete cooperation in fulfilling its obligations in all phases of the study, by providing us with access to relevant documentation and making efficient arrangements for interviewing personnel at the FAA Headquarters, the FAA Academy, and field sites. The assistance that was received from all FAA personnel was excellent, and consistent with the general observation that they are dedicated to the fulfillment of their operational and training mission in the best professional manner and are eager to receive recommendations for improvement.

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A STUDY OF TRAINING PROGRAM IMPROVEMENTS

Volume I: Findings and Analyses

Chapter 1

INTRODUCTION AND OVERVIEW OF FINDINGS

PROBLEM

The maintenance training mission of the FAA Academy in Oklahoma City, Oklahoma, continues to increase as new air traffic control equipment is acquired. New maintenance concepts must be derived, for which training requirements are then developed to enable the technical training system to produce maintenance personnel who can perform effectively. If the amount of operational equipment were small, the technical training system could be easily evaluated to determine whether the training being given at the Academy and the training equipment procured matched that required by the maintenance concepts, and if the training system, itself, were meeting these requirements in an economical way. However, with the rapid increase in air traffic technology, the validity and efficiency of the present technical training system become more difficult to determine without embarking on a systematic study.

The purchase of training equipment involves problems that illustrate the complexity of the problem. Procurement of a new operational device does not necessarily mean that the same device should be procured for maintenance training, or that the present system is not producing training outcomes that match the maintenance concept that applies to the new operational equipment. The present system may already have a combination of courses and equipment which meets the training outcomes that apply to the maintenance of a newly acquired operational device. Therefore, the addition of the new operational equipment may not require changes in the present training system.

Another example of the complexity of the problem is the question of the extent to which valid training requirements are being met in a cost-effective way. With an increase in the amount of operational equipment, maintenance concepts, training requirements, training devices and aids, and instructional technology, the system must be evaluated to determine whether it is meeting valid training requirements economically.

In order to fully examine the training system and to determine when and how to improve it, the FAA awarded a contract (Contract No. DOT FA71WA-2687) to the Human Resources Research Organization (HumRRO).

The course structure, career progression patterns, presently available training aids and devices, instructional methods, equipment procurement criteria, and all other components of the training system were evaluated to determine whether the resources and procedures available to the FAA Academy are being used in the most cost-effective manner.

The description of the evaluation methods, and the findings are presented in this report, Volume I of the final report. Specific recommendations for improvement in the FAA's Air Navigation Facilities (ANF) Maintenance Training Program are presented in Volume II.

SUMMARY

The purpose of the investigation of the ANF Maintenance Training Program was twofold. First, a comprehensive study was undertaken to determine areas where the

program could be improved in its effectiveness and in its cost. Secondly, recommendations were constructed based on the study and a plan was devised to implement the recommendations for improvement in the training program.

The study of the Academy's ANF Maintenance Training Program was undertaken by the study of 10 courses of instruction, two in each of the five major career fields: communications, data processing, navigational aids, electromechanical, radar. It was expected that the information developed in the study of the 10 courses would be a sufficient sample of the training system on which to base general conclusions. The examination of the courses necessarily required the collection and study of documents pertaining to the operation of the training system in its entirety. Consequently, the documentation collected and studied resulted in the investigation of systems and processes that went far beyond the characteristics of any given course or collection of courses. Nonetheless, in all cases conclusions that were drawn were tempered with the strong awareness of any restrictions that should be imposed due to the amount of actual data collected bearing on any given problem area.

SPECIFIC OBJECTIVES

The first task (A) was the investigation of the overall training philosophy. This was performed by comparing maintenance concepts with training outcomes that are required to be achieved in the 10 courses that were examined. Next the 10 courses were to be examined to determine the amount of time spent in each which could be justified on the basis of training outcomes which are required and that are directed towards fulfillment of a maintenance concept. Another component of this task was the determination of the degree of duplication of topic coverage among major training program areas. This went beyond the investigation of the 10 courses which were the focal point of the investigation to include all the courses in the training path of the courses originally selected.

The second task (B) required that the specific instructional activities in 11 areas—for example, the use of job analyses, training plans, lesson plans, instructor productivity measures—be compared with the kinds of instructional activities that should be carried on in order to meet the training outcomes demanded by the maintenance concepts.

The third task (C) involved the study of the criteria and standards governing the purchase and installation of equipment at the Academy for maintenance training purposes. Among the factors evaluated in the study of the criteria and standards were current equipment investment, the utilization of training equipment, factors governing decisions to furnish equipment, equipment retirement criteria, effectiveness of using operating equipment at field sites for training, and the effectiveness of using regional employees as on-the-job training personnel. The results of Task C were to be a description of the present system, and an evaluation which would lead to specific suggestions for improvement.

The fourth task (D), was the evaluation of the effectiveness of various teaching methods that are used to produce the training outcomes required in the courses. In particular, the effectiveness and efficiency of resident training, directed study, and on-the-job training were examined. As a part of this task the relative costs of the various alternative methods that could be used for training were evaluated, as well as a number of other equally important factors.

The final task was the construction of the reports. The present volume (I) is a detailed report of the study objectives, methods of investigation, and conclusions. The companion volume (II) contains specific recommendations for the improvement of the training system and a plan for the implementation of the recommended improvements.

METHODS OF PROCEDURE AND FINDINGS

GENERAL PROCEDURES

Three basic procedures were used to accomplish the work. The first was the collection of documentation on the training system, relevant maintenance concepts, relevant job analyses, manufacturers' equipment instruction manuals, course control documentation, and all other records and documents which bore directly on the examination of the training system. Second, a number of data collection instruments were constructed for the purpose of assessing the adequacy of the instructional system. This was done because in a number of areas the documentation was not appropriate for the collection of information that was needed to satisfactorily perform the investigation. Third, research personnel made on-site investigations at the FAA Academy, at locations where on-the-job training was being performed, and at FAA headquarters in Washington, D.C.

The specific methods used to perform the various work tasks were tailored to meet the type of problem being investigated and the available documentation, and in all cases maximize the amount of information that could be extracted within the scope of the investigation, and some cases went beyond the prescribed scope.

VALIDATION OF TRAINING PHILOSOPHY (Task A)

The examination of the validity of the overall training philosophy was achieved by examining the maintenance concepts which pertained to the 10 courses that were to be evaluated and comparing these concepts with the training outcomes required in each course. Through this analysis, it was expected that the amount of time spent in each course devoted to the required maintenance capability could be determined.

The first finding was that only three maintenance concept documents were found to exist out of the 10 documents that were sought, and one of the documents did not pertain to the actual end item equipment which was to be maintained by trainees after they had finished the course. Since much of the performance of the project actually rested on the availability and use of the Maintenance Concepts, some substitute was sought for them.

Job Analyses were available in two cases where maintenance concepts were not, although in one course, the Doppler Direction Finder, the job analysis document did not directly apply to the Doppler DF that was the end item of equipment to be maintained when finishing the course. Two other courses which did not have pertinent job analyses documents available for use were courses in principles; it is questionable as to whether they should have job analysis documents available, or available in the same form as they might be for use in the development of courses oriented to equipment maintenance.

This information was used to compile tables showing training outcomes required in the various courses which were validated by either a maintenance concept or a job analysis document.

The next step in the analysis was the examination of the length of the courses. This was accomplished by identifying course hours presently allocated to the instruction of material that could be identified with training outcomes that had been validated either by Maintenance Concept or Job Analysis information. It was found that no more than 6.7% of the total resident training time could be supported by existing Maintenance Concept and Job Analysis documentation.

However, since the analysis necessarily required the availability of maintenance concepts and job analyses, the very lack of such documentation definitely means that this percentage cannot be presently accepted as a reliable indication of excessive course lengths.

The duplication of topic coverage among the major training program areas was examined. The first step in this analysis was the development of an understanding of the structure of the training progression patterns within each career field based on the prerequisites specified in the combined agency catalog. The second portion of the effort was to determine the policies for movements across career fields. The structure of the training progression patterns was developed using the catalog prerequisite information, lesson plans, and training manuals. All topics in each course in the training path in a given career field were compared with the topics covered in all courses within that training path to determine the areas of duplication of topic coverage. The evaluation of the extent of topic duplication is extremely detailed and is reported at the level of individual lessons in all cases.

EVALUATION OF THE INSTRUCTIONAL PROGRAM (Task B)

Eleven instructional or instructionally related activities were examined to determine whether they were appropriately utilized to meet the training requirements imposed by the maintenance concepts in each of the 10 courses. Since there were only a few training outcomes validated by either maintenance concepts or job analysis documents, no conclusions could be drawn from the task as originally defined. Consequently, the scope of the task was extended to an investigation of the activities from the general considerations of instructional technology.

By expanding the scope of the task in this way, it was possible to obtain a reliable evaluation of the Academy's response to the training outcomes that are required. The assumption was that the instructional mission would be met with the same efficiency, whether or not training outcomes were valid. Therefore, this analysis can be viewed as a moderately independent assessment of how the Academy's ANF Maintenance Training Branch responds to training outcomes which their students are expected to achieve. The dominant finding in each of the areas was:

(1) Job Training Standards and Maintenance Concepts play a minor role in the preparation of lesson material.

(2) The analysis of training objectives depends primarily upon the use of training plans as a source for guidance in the construction of course materials. The training plans do not contain sufficient detail to permit course developers to effectively develop curricula. Consequently, the individual instructor has considerable latitude in selecting what will be taught in a course. For example—the resident outline for the MARK I ILS course indicated that eight hours would be devoted to the topic "Special Solid State Devices and Circuits." But there is no indication as to what content will be taught (the specific set of devices and circuits), or the objectives of the instructions (theory, repair, P.M., etc.); nor are there references (FAA standards or Handbooks) for the person developing the Instructor Guide to consult to derive the content.

(3) Training plans were available in all courses, although they varied considerably in their content and potential utility.

(4) Instructor Guides were available in various formats in each of the 10 courses. They differed greatly in the amount of detail and potential value to the instructor. Generally, they do not contain sufficiently well-specified requirements or objectives to guide the instructor and to direct the student.

(5) Lesson plans tend to be the instructor's handwritten notes. Generally, they do not specify what he should expect the students to learn as a consequence of a given lesson or part of the lesson. Consequently, the student or class may not learn what is specifically expected, where their attention is to be directed, and which goals they are expected to achieve.

(6) Through an examination of plans of instruction, lesson plans, Instructor Guides, lesson guides, lectures, and direct observation of the presentation of instruction, it was found that the contents of lessons generally match what is supposed to be taught in a class during a given class hour. However, the materials are deficient in some respects. For example, some of the materials contain errors, and the Instructor Guides do not provide sufficient indication of the amount of time that should be spent on various subtopics within the lesson.

(7) The quality control of instruction needs to be improved. However, the problem seems to be a systematic one, and not necessarily one which has its origins in the Academy's ANF Maintenance Training Branch, itself.

An effective quality control system requires that the training program itself be built upon a detailed statement of training objectives based on job requirements, accurate and appropriate measures of student proficiency, effective communication among students and instructors on the performance of students on tests, effective procedures for corrective action, if necessary, and supervisory support.

While it might appear as though all of these components of the quality control system are presently operating in the Academy's training structure, they are not. The problem is simply that well-specified detail of what is required by way of Maintenance Concepts, Job Analysis documents, and training objectives does not presently exist, nor do accurate and appropriate measures of expected proficiency on maintenance tasks themselves exist in any documented form.

This situation renders ineffective any mechanism that might exist for taking corrective action to bolster the training program in areas where it may be deficient. The specific information which is needed to give effective supervisory support and direction is also, therefore, absent and leaves the matter of the judgment of quality and the direction of supervision open to considerable individual interpretation and action.

(8) The student/instructor ratio can be increased in some instances. The lecture method is the predominant teaching mode used at the Academy. Should there be a great deal of discussion among instructor and students during lectures, it would be necessary to have relatively small classes in order to have an effective course. However, direct observation of the conduct of lectures shows that there is very little interchange between student and teacher, therefore the present ratios in lectures are no problem. Indeed, a considerably greater number of students could be placed in classrooms to listen to the presentations of a single instructor.

Laboratories are another matter. Direct laboratory observation indicated that different content and different laboratory instructional techniques demand different numbers of instructors, depending upon the individual situation. If the laboratory is to be well designed, giving highly individual attention to the student, then in some courses the laboratory experience could be improved through increasing the number of laboratory instructors. However, the content of the present laboratory experiences needs to be evaluated before decisions should be made on increasing or decreasing the teaching manpower employed in laboratories.

(9) The instructors are generally capable, but should use audio-visual aids to a greater extent.

(10) The productivity of instructors is not under control. While it may be that they are productive, the allocation of their time to various tasks is not being documented, and the achievement of the instructor in such tasks as assisting in the development of training plans, preparing courses, and so forth, is not a matter of record. A

consequence is that the allocation of manpower or the projection of manpower needs in the branch is not based on the documented actual amount of time required to perform legitimate instructional tasks. The amount of time that should be allocated to instructional tasks should be flexible, and should account for variation in the difficulty of the task, and the amount of time actually spent. The amount of time projected to be spent on tasks should be capable of defense by supervisory personnel. The defense should not be based on rigid formulae.

(11) The instructor development program addresses relevant topics and should provide the necessary preparations for the instructor.

(12) The effectiveness of the instructors could be increased if the system provided the basis for additional supervision through the specification of course objectives and the use of measures to control and guide productivity of instructors.

STUDY AND EVALUATION OF THE ACADEMY'S EQUIPMENT REQUIREMENTS (Task C)

The criteria and standards governing the purchase and installation of equipment at the Academy for maintenance training purposes were studied and evaluated. The task was performed by researching FAA documentation and interviewing key personnel.

A procurement policy does exist. However, it is not accompanied by a formally defined procedure for its execution. The policy should be augmented by statements describing how it is to be implemented. Standards and criteria need to be developed in order to derive an objective means for weighing and evaluating the various factors that must be taken into account to determine when equipment should be purchased and retired.

An estimate of the effectiveness of the present procurement process was undertaken by determining the necessity for the purchase and location of prime equipment at the Academy for use in each of the 10 courses being examined.

In general, the location of prime equipment at the Academy is required for training purposes if attention is focused solely on the training outcomes that are presently required without questioning their validity. However, if the analysis is restricted to the examination of the need for the location of prime equipment to meet training outcomes that have been validated by maintenance concepts, then the finding is that there is little evidence to indicate that prime equipment needs to be located at the Academy for training purposes. However, this last finding is very likely to be only an accident of the fact that there are very few maintenance concepts.

Additional procurement considerations were studied to gain a more complete understanding of the factors that influence equipment procurement decisions. These included the following considerations:

(a) Similarity of equipment presently at the Academy to equipment being considered for procurement.
(b) Longevity of the training requirement.
(c) On-the-job training at site.
(d) The utility of using the prototype equipment for training purposes rather than the first production model.
(e) The procedure of training maintenance personnel in advance of the requirement to place them in the field.
(f) The alternative to either purchase or borrow equipment from the field or production line.

While the basic results of this study task are described in the present volume, the conclusions take the form of recommendations and are described fully in Volume II of this report.

EXAMINATION OF TRAINING METHODS AND RECOMMENDED ALTERNATIVES (Task D)

The various training methods available to the ANF Maintenance Training Branch were examined to determine their relative effectiveness in producing valid required training outcomes. Since there were so few required training outcomes that could be validated by maintenance concepts and job analyses documents, the scope of the analysis was broadened to include all training outcomes independent of their validity. The 10 courses were examined to determine the relative effectiveness of resident training, directed study, on-the-job training, and programed instruction.

At this stage of the study, no consideration was given to the potential costs of the methods. The problem of costs, however, was not ignored. In those cases where an apparent costly instructional technique was considered to be appropriate, the recommendation to implement the apparent costly method is discussed in detail in Volume II of this report along with an analysis of the cost benefits of implementing the form of instruction.

Resident instruction was generally considered the most effective means to accomplish the training outcomes in 8 of the 10 courses. However, in two *principles* courses, although they contain laboratory exercises, programed instruction was ranked highest by the research staff, and a detailed case was made for the implementation of programed instruction in these instances and any others with similar characteristics.

Another aspect of this task was the estimation of the relative costs of the various methods of training which are available to the Academy. The categories of instruction that were examined included resident training, OJT, and directed study. It was found that the training plans provided by the FAA were the principal sources of cost data. However, these data did not prove to be very helpful because the types of training that were being examined typically are directed toward different performance objectives so cost comparisons among them were not meaningful. For example, cost data were not available for OJT and DS for the same performance objectives. Consequently, an alternate approach was adopted to determine the relative costs of the alternative methods. The approach was based on a model situation that could be analyzed with respect to the various training methods. This allowed the development and presentation of factors and processes which are involved in the making of comparisons of this type, and the indication of the kinds of information that the FAA might develop in order to more effectively develop cost information.

Based on this and similar analyses, the possibilities for improving instructional techniques to increase the effectiveness of the methods and reduce the overall costs were identified. Since the results of this analysis took the form of recommendations, this material is presented in Volume II of the report.

The practicability of using commercial sources of training was also examined by comparing the relative costs and effectiveness of out-of-agency training against the costs and effectiveness of comparable courses offered at the Academy. The scope of this task was restricted to an examination of the 10 courses that had been selected for detailed analysis.

Only one course, No. 42002, for the ARTS III fulfilled the data requirements and scope of the study. For this single case the evidence suggested that the costs of ANF-conducted training would be less for comparable training that might be procured

from commercial sources. However, this observation should not be viewed as general because of the lack of cases for examination.

Training course development costs were also examined to determine the practicability of using various combinations of FAA and contractor resources to develop and administer training courses. Study of this problem revealed, generally, that there is no indication that any change should be made in the present system towards the more extensive use of contractor-conducted training for instructors as a means for reducing course development costs.

Contractor-furnished training courses and materials were contrasted in cost to the Academy conducting courses which used data supplied by the contractor. The scope of this task was restricted to the analysis of FAA-furnished cost figures for courses presently taught at the Academy for which contractor cost data were also available.

No case was identified where the contractor had developed the appropriate material. Consequently, the analysis could not proceed further. However, the scope of the task was increased and an alternative method was used to examine course development costs. The training plans for the ARTS III and the Wilcox Mark I ILS course were examined in the hope that some information could be obtained from the cost data developed in conjunction with the development of their training plans.

Even in these cases, the appropriate data were absent and it was not possible to derive relative costs for the development of training courses or to suggest changes to the present system which might prove to be cost effective. Consequently, the type of data that should be developed by the FAA to permit this type of analysis is described and discussed in Chapter 5.

CONCLUSIONS

Improvement of the Air Navigation Facilities Maintenance Training System depends upon factors that are not only internal to the ANF Maintenance Training Branch, but also go considerably beyond the authority and capabilities of the branch. Even though the basic regulations that prescribe the training system and the types of documentation that are to be used are fundamentally sound, basic difficulties arise from two sources which impact on the operation of the ANF Maintenance Training Branch and the quality of the technician who is sent to the field to service air navigation facilities.

First, based on the sample of 10 courses, it is clearly the case that Maintenance Concepts and Job Analyses that may be used to construct training programs have not been produced, or updated as the case may be. The effects of the lack of this fundamental documentation, or a recognized and standardized substitute, are visible throughout the entire training system. One effect is that training outcomes being required are determined on information of varying or unknown accuracy.

An additional consequence of this lack of formalization is that plans of instruction, Instructor Guides, and other instructional materials may lack validity and the level of specification that is required to ensure that the men get proper training, and that instructors are, themselves, developing and administering training materials that are valid and efficient.

In the absence of a documented specification of valid and detailed information of job and training requirements, instructors and their unit chiefs respond to training requirements using the knowledge that is at their command. The latitude in the construction of course materials is so extensive that supervision of the individual instructor is a difficult task. This problem is intensified by difficulties which are intrinsic to the ANF Maintenance Training Branch itself. For example, existing regulations governing the

construction of course materials are not always followed, and the productivity of the instructors is not under the documented control of their supervisors.

Analysis of the content of the 10 courses in the context of their respective training paths shows that some duplication of course topics exists. Also, there is a general lack of maintenance-oriented instruction in favor of emphasis on theory and normal operation of equipment. A more realistic specification of job requirements and training requirements would very likely require the removal of a great deal of the theoretical material and a reorientation of the courses toward troubleshooting.

The lack of appropriate formal documentation of job and training requirements has an impact on the training equipment procurement process. Since the early 1960's, the United States Air Force Systems Command has employed a very formalized system[1] for obtaining detailed data on personnel, training, and training equipment requirements from equipment manufacturers during the early conceptualization and developmental phases of new equipment acquisition. These data are used, for example, to develop a Training Equipment Planning Information (TEPI) report which the contractor is required to prepare and submit after award of the contract.

Training equipment can be procured in a cost-effective way if, among other things, a thorough analysis has been made of the specific skills and knowledges that the technician must have in order to perform his job, and the minimum entry level performance standards are specified. If this information is available, prudent choices can be made about the necessity to establish and structure a new course, utilize existing equipment for training purposes, and select appropriate training methods. This information is not available at present.

Another major area that should be improved is the quality control of instruction. While information from the field is returned to the Academy for purposes of evaluation of course effectiveness, the type of information that is transmitted is insufficient for a sound evaluation of the training program or any individual course. Since maintenance concepts, job analysis, and job standards either are not available or are not generally specified in any detail, there is really no way for one to compare the performance of men at the conclusion of a course with the performances that they are expected to exhibit upon reporting for duty at an FAA installation. Therefore, the specific kinds of information that are needed to upgrade and reformulate training and specific courses of instruction do not reach Academy personnel in a usable form. Neither the System Maintenance Service or Technical Training Division receive information which they need to assess the effectiveness of the program.

Instructors and their supervisors are generally capable men who are qualified for their responsibilities. Nonetheless, observation of classroom instruction and the study of documentation indicates that the instructors could benefit from additional training in the use of audio-visual aids, and should adhere more closely to Academy regulations governing the form of course documentation.

Generally, the various training methods available at the Academy are used appropriately. Resident training is typically the most appropriate cost-effective procedure. Use of programed instruction is sound in courses involving instruction in basic principles. Programed instruction is being attempted in appropriate areas. However, the quality of the material can be upgraded. The cost of the construction of programed instructional materials is an important concern. Cost factors and formulae which can be used in making decisions to develop programed instruction materials are included in Volume II of the report.

The methods, findings, and conclusions are presented in detail in the succeeding chapters of this volume.

[1] For further information, the reader is referred to AFSC Manual 80-3.

Chapter 2

VALIDATION OF OVERALL TRAINING PHILOSOPHY (TASK A)

OBJECTIVE

The objective of this task was to determine the validity of training outcomes from a study of relevant maintenance concepts.

METHOD

The first step in accomplishing the required objective was to select two courses of instruction taught within the Air Navigation Facilities Maintenance Training Branch at the FAA Academy of varying levels of difficulty within each of five career fields:

(1) Communications
(2) Data Processing
(3) Navigational Aids
(4) Electromechanical
(5) Radar

The data presented in this section were subsequently used in further analyses such as course length.

An additional constraint on the selection of the courses was the requirement that any course selected had to have a class in session during the two-week instructional observation period.

The courses selected that met the required conditions were:

Career Field	Course No.	Weeks	Title
Communications	40001	12	Communications Equipment (CE)
Communications	40210	2	VHF/UHF Direction Finder (DF)
Data Processing	43411	6	NAS En Route Automation I/O Equipment for Technicians I/O
Data Processing	43413	36	IBM-9020 Central Computer Complex (9020)
Navigational Aids (Navaids)	40200	8	Rho-Theta (TACAN) Principles (TACAN)
Navigational Aids	40216	6	Wilcox Mark I ILS Equipment (Wilcox) (Interim)
Electromechanical	40104	3	Integrated Program for Diesel Engine Generators (DEG)
Electromechanical	40115	2	Solid-State Fundamentals for Electro-Mechanical Career Field (SSF)

Career Field	Course No.	Weeks	Title
Radar	40318	4	Integrated Program for ATCBI-3 Transmitter/Receiver — Indicator Site (ATCBI)
Radar	42002	18	Automated Radar Terminal System, ARTS III for Technicians (ARTS III)

Once the courses had been selected, the next step was to obtain the related maintenance concepts. Personnel of the Systems Maintenance Service (SMS) were contacted for this purpose. Of the 10 courses selected, eight were equipment-oriented courses. Systems Maintenance Service was able to provide three maintenance concepts, as follows:

Course No.	Document Title
40104	1. Maintenance concepts for Standby Engine Generators
42002	2. Maintenance concept for ARTS III Automated Terminal Radar System (24 April 1970)
43411	3. CDC and CUE Maintenance Concepts and Guidelines (April 2, 1969) which was found not to be appropriate since CUE was explicitly not included in the training plan for this course.

In addition, SMS supplied job analysis documents as follows:

Course No.	Document Title
40001	1. Remote Center Air Ground and Remote Transmitter/Receiver Facilities (RCAG)
40318	2. Secondary Radar (SECRA)
40200	3. Rho-Theta Transponder Beacon System (TACAN)
43413	4. Central Computer Complex Technician
40210	5. Very High Frequency Direction Finder Electronic Maintenance
40210	6. Ultra High Frequency Direction Finder
	(These two job analyses were not for the Doppler equipment taught in the course.)

The two relevant and appropriate maintenance concepts were then studied. The determination of the validity of the training outcomes as they appear in the FAA Combined Agency Course Catalog was then made by searching the appropriate maintenance concept for words, phrases, or sentences that were directly reflected in the training outcomes. If such could be found, the fact was noted. If such could not be found, that fact was also noted adjacent to the training outcome under study.

Since only two maintenance concepts were available for the 10 courses, the validation of training outcomes utilizing maintenance concepts would not be performed for eight of the 10 courses. Of the remaining eight courses, six had job analysis

documents which were used in place of maintenance concepts. Two of the eight courses were principles courses and had neither job analysis documents nor maintenance concepts.

In addition to indicating the validity of the training outcome, the Job Analysis documents were also examined with respect to implied training outcomes which were not stated in the catalogue as training outcomes. These were also listed, along with references to specific statements that implied these outcomes in the Job Analysis documents.

RESULTS

The results of the analysis are tabulated in the tables which follow. Table 1 of the analysis consists of a listing of the courses, a short description of them and comments relating to sources used for the validation process. Table 2 consists of the tabulated results, with explanatory notes. Perusal of the tables shows that there is only one training outcome found to be valid by examination of the maintenance concepts. This occurred in the ARTS III program.

Table 1

DESCRIPTION OF COURSES AND COMMENTS

FAA Course Catalog No. 40216

Course Description

Course No. 40216, Interim Wilcox Mark I ILS Equipment is a resident course taught at the FAA Academy; 240 hours (6 weeks) in length.

Comments

There is no maintenance concept available for the Wilcox Mark I ILS equipment.

FAA Course Catalog No. 40200

Course Description

Course No. 40200 Rho-Theta (TACAN) Principles (FD-200) is a resident course conducted by the FAA Academy; 320 hours (8 weeks) in length.

Comments

This is a principles course with no specific maintenance training outcomes indicated. There is no Maintenance Concept in existence for TACAN equipments. There is no Job Analysis document specific to RTN-2 TACAN equipment available.

(Continued)

FAA Course Catalog No. 40001

Course Description

Course No. 40001 Communications Equipment (FC-100) is a resident course taught at the FAA Academy; 480 hours (12 weeks) in length.

Comments

There is no maintenance concept available for the equipments taught in this course.

Although there is no maintenance concept available for the equipments taught in the course, a Job Analysis document was provided for the Remote Center Air Ground and Remote Transmitter/Receiver Facilities. The job analysis document does not identify the specific equipments upon which maintenance is performed.

Analytical Assumptions

For the purposes of the analysis, it is assumed that the job analysis document refers to equipment items taught in the 40001 course.

FAA Course Catalog No. 40210

Course Description

Course No. 40210 VHF/UHF Direction Finder, FA-5530 (VHF/UHF DF) is a resident course taught at the FAA Academy; 80 hours (2 weeks) in length.

Comments

There is no maintenance concept available applicable to the Doppler type VHF/UHF Direction Finder equipment taught in this course.

Because no maintenance concept was available, the training outcomes listed in the course catalog could not be validated using that source. However, two Job Analysis Documents were provided and used in an attempt to determine if the training outcomes in the catalog were derivable from these sources. It should be noted that the Job Analysis documents did not apply to the Doppler DF of the course.

FAA Course Catalog No. 40104

Course Description

Course No. 40104 is the Resident Course conducted by the FAA Academy. It is part of "Integrated Program for Diesel Engine Generators" maintenance, Catalog No. 40103. This program consists of (a) Course No. 44102, Directed Study Phase; 25 hours, (b) Course No. 43650, On-the-Job Training; 16 hours, (c) Course No. 40104, Resident Course; 120 hours, and (d) Course No. 43651, On-the-Job Training.

Comments

Since a Maintenance Concept, "Maintenance Concepts for Standby Engine Generators," was provided, this document was used as the sole source for validation of the training outcomes provided by the catalog.

(Continued)

FAA Course Catalog No. 40115

Course Description

Course No. 40115 Solid State Fundamentals for Electro-Mechanical Career Field is a resident course in solid state fundamentals conducted by the FAA Academy; 80 hours (2 weeks) in length.

Comments

This is a fundamentals course and is not directed toward preparing the technician to maintain a specific equipment or system. There is no maintenance concept available. Because of this fact, it is impossible to validate the training outcomes as listed in the course catalog.

FAA Course Catalog No. 43411

Course Description

Course No. 43411 is the resident course conducted by the FAA Academy. It is part of "Integrated Program for NAS En Route Automation I/O Equipment for Technicians (FPI-165)," Catalog No. 43410. This program consists of (a) Course No. 43805, OJT-1; (b) Course No. 44408, Directed Study (FPD-165); (c) Course No. 43411, Resident (FP-165) and (d) Course No. 43806, OJT-II (FPO-165-II). The program is currently being planned. Resident course covers all phases; 280 hours (7) weeks in length.

Comments

The maintenance concept supplied is entitled "CDC and CUE Maintenance Concepts and Guidelines." The training plan for Course 43410, dated February, 1971, specifically states that CUE training is not included. Neither maintenance concepts documents pertaining to the actual equipment of the 43410 course, nor Job Analysis documents were available.

Analytical Assumptions

Since a maintenance concept or job analysis for the equipment of the 43410 course were not available, validation of the training outcomes cannot be performed. The maintenance concept for the CUE/CDC is not applicable to the equipment of the 43410 course.

FAA Course Catalog No. 43413

Course Description

Course No. 43413, IBM-9020 Central Computer Complex is a resident course taught at the FAA Academy; 1440 hours (36 weeks) in length.

Comments

There is no maintenance concept available for the equipment taught in the IBM 9020 course.

Because no maintenance concept was available, the training outcomes listed in the course catalog could not be validated using that source. However, a job analysis document was made available. Using that document, an analysis was performed to validate the training outcomes.

(Continued)

FAA Course Catalog No. 40318

Course Description

Course No. 40318 is the resident portion taught at the FAA Academy of Course No. 40317, Integrated Program for ATCBI-3 Transmitter/Indicator Site. This program consists of (a) Course No. 44316, Directed Study; 15 hours, (b) OJT-I, Course 43756; 45 hours, (c) Resident Training, Course No. 40318; 160 hours, and (d) OJT-II, Course No. 43757; 21 hours.

Comments

The training outcomes as listed in the course catalog do not specify which portion of the program they apply to. There is no maintenance concept available for the ATCBI-3 equipment.

Analytical Assumptions

It is assumed that the training outcomes listed in the course catalog apply to the resident program.

Because no maintenance concept was available, the training outcomes listed in the course catalog could not be validated using that source. However, a job analysis document for SECRA (Secondary Radar) was provided and was used in an attempt to determine if the training outcomes in the catalog were derivable from this source. It should be noted that the job analysis document was not intended to be specific to a particular equipment. Within the limitations of this document, an analysis was performed.

FAA Course Catalog No. 42002

Course Description

Course No. 42002 is the resident course conducted by the FAA Academy. It is part of "Integrated Program for Automated Terminal Radar System, ARTS III for Technicians." The program will consist of (a) Directed Study, 48 hours, (Course number not yet determined); (b) On-the-Job Training, Phase I, 24 hours, (Course number not yet determined); (c) Resident Course No. 42002; and (d) On-the-Job Training, Phase II, 48 hours (Course number not yet determined). Resident course is 720 hours (18 weeks) in length.

Comments

The maintenance concept supplied is entitled "Federal Aviation Administration Maintenance Concept for ARTS III Automated Terminal Radar System," dated 24 April 1970. The training outcomes in the catalog are not specific as to the course to which they apply.

Table 2

TABULATED RESULTS

Course No. 40216

Interim Wilcox Mark I ILS Equipment	**Maintenance Concept Validated Training Outcome?**		
Upon completion of this program, the trainee should be able to:	Yes	No (Why)	Unable to Determine
1. Locate and identify all subassemblies and controls.			X[a]
2. Perform all maintenance checks and adjustments.			X[a]
3. Recognize, analyze, localize, and correct all deficiencies and malfunctions.			X[a]
4. Operate all related test equipment and tools.			X[a]
5. Evaluate the effects of related equipment.			X[a]
6. Analyze the operation and functions.			X[a]
7. Assume full maintenance responsibility.			X[a]

[a]Since there is no maintenance concept available for this equipment, it is not possible to validate the training outcomes in the catalog on that basis.

There was no job analysis available that could be used as a substitute for the maintenance concept. Accordingly, training outcomes could not be validated against either a maintenance concept or a job analysis document.

Course No. 40200

Rho-Theta (TACAN) Principles (FD-200)	**Maintenance Concept Validated Training Outcome?**		
Upon completion of this course, the trainee should be able to:	Yes	No (Why)	Unable to Determine
1. Identify and explain the operation of the RF and magnetic devices used in the RTN-2 TACAN equipment.			X[a]
2. Recognize and evaluate the waveshaping amplification and pulse circuitry in the TACAN equipment.			X[a]

[a]Since there is no maintenance concept, it is impossible to determine the validity of the training outcomes as given in the course catalog.

(Continued)

Course No. 40001

Communications Equipment (FC-100)	Maintenance Concept Validated Training Outcome?		
Upon completion of this course, the trainee should be able to:	Yes	No (Why)	Unable to Determine
1. Analyze and repair electronic communications equipment by use of schematic diagrams and cause-and-effect reasoning.			X[a]
2. Evaluate telephone control and communications lines operation by performing line runs.			X[a]
3. Inspect, clean, adjust, and repair telephone type relays.			X[a]
4. Utilize standard test equipment to measure performance and speed servicing of communications equipment.			X[a]
5. Analyze, service, and check performance of FAA communications receivers.			X[a]
6. Analyze, tune, and load FAA Communications type transmitters.			X[a]
7. Understand the theory of operation of communications equipment.			X[a]

[a]Since there is no maintenance concept available for the equipments taught in this course, it is not possible to validate the training outcomes from that source.

(Continued)

Course No. 40001

Communications Equipment (FC-100)	Job Analysis Document Validated Training Outcome?		
Upon completion of this course, the trainee should be able to:	Yes	No (Why)	Unable to Determine
1. Analyze and repair electronic communications equipment by use of schematic diagrams and cause-and-effect reasoning.		X[a]	
2. Evaluate telephone control and communications lines operation by performing line runs.		X[b]	
3. Inspect, clean, adjust, and repair telephone type relays.		X[c]	
4. Utilize standard test equipment to measure performance and speed servicing of communications equipment.		X[d]	
5. Analyze, service, and check performance of FAA communications receivers.	X[e]		
6. Analyze, tune, and load FAA Communications-type transmitters.	X[f]		
7. Understand the theory of operation of communications equipment.		X[g]	

[a]Job analysis document does not state requirement to use schematic diagram.

[b]Job analysis document makes no reference to telephone control and communications lines evaluation duties.

[c]Job analysis does not address telephone type relays maintenance duties.

[d]No reference to requirement for speeding servicing of communications equipment.

[e]Yes; see duty 12, Receivers.

[f]Yes; see duty 4, 5, Transmitters.

[g]Understanding theory of operation not explicitly called for.

(Continued)

Course No. 40001

Training Outcomes Implied by Job Analysis Document Not Included As Catalog Training Outcomes

		Job Analysis Ref: Duty Number
1.	Perform system evaluation in connection with flight inspection	17
2.	Perform system evaluation (Sector)	18
3.	Certify system	19
4.	Train ATM personnel in operation	20
5.	Perform system evaluation and certification in connection with aircraft accident	21
6.	Perform equipment modifications	23
7.	Evaluate test equipment	24
8.	Maintain records	25
9.	Service rack motors	26
10.	Service engine generator	27
11.	Inspect A.C. supply voltage regulators	28
12.	Inspect buildings	29

Course No. 40210

VHF/UHF Direction Finder, FA-5530 (VHF/UHF DF)	Maintenance Concept Validated Training Outcome?		
Upon completion of this course, the trainee should be able to:	Yes	No (Why)	Unable to Determine
1. Explain the complete theory of operation.			X[a]
2. Evaluate the operation and performance of the equipment.			X[a]
3. Diagnose and correct equipment malfunctions.			X[a]
4. Perform all maintenance checks and adjustments in accordance with current operating standards.			X[a]
5. Perform a full system alignment.			X[a]
6. Properly use all facility test equipment.			X[a]

[a]Since a maintenance concept was not available for this equipment, it is not possible to validate the training outcomes in the catalog on that basis.

(Continued)

Course No. 40210

VHF/UHF Direction Finder, FA-5530 (VHF/UHF DF)	Job Analysis Document Validated Training Outcome?		
Upon completion of this course, the trainee should be able to:	Yes	No (Why)	Unable to Determine
1. Explain the complete theory of operation.		X[a]	
2. Evaluate the operation and performance of the equipment.	X[b]		
3. Diagnose and correct equipment malfunctions.	X[c]		
4. Perform all maintenance checks and adjustments in accordance with current operating standards.	X[d]		
5. Perform a full system alignment.		X[e]	
6. Properly use all facility test equipment.	X[f]		

[a]The job analysis documents provide no evidence that an ability to explain theory of operation is required as a function of the job.

[b]Duties 12 and 13 of VHF Job Analysis, and Duties 16 and 17 of UHF Job Analysis (Flight inspection, and ATFO inspections) relate to this training objective.

[c]Yes, see, for example, duty 6 (Receiver) VHF DF.

[d]Maintenance checks and adjustments are called for in a variety of duties, for example Duty 3, ASR Adapter Unit. However, reference to current operating standards is implicit.

[e]Full system alignment is not called for. Performs receiver alignment, duty 7, in VHF, and UHF. Aligns Target Transmitter in UHF, duty 14.

[f]Duty 23 in UHF is specific to evaluation of test equipment.

Course No. 40210

Training Outcomes Implied by Job Analysis Documents But Not Included as Training Outcomes in the Catalog

Training Outcome	Job Analysis Ref: Duty Number
1. Certify normal operation of system	18
2. Evaluate and certify facility in connection with aircraft accident	21
3. Perform equipment modifications	22
4. Maintain proper records of facility operation and performance	24
5. Service building and equipment rack motors	25
6. Service engine generator	26
7. Inspect condition and operation of AC supply voltage regulators	27
8. Inspect condition of building and antenna shelter	28

(Continued)

Course No. 40103

Integrated Program for Diesel Engine Generators	Maintenance Concept[a] Validated Training Outcome?		
Upon completion of this course, the trainee should be able to:	Yes	No (Why)	Unable to Determine
1. Locate and describe the function of control panel components.		X[b]	
2. Perform a no-load and full-load test on an engine generator.		X[c]	
3. Demonstrate and explain safety precautions associated with diesel engine generators.		X[d]	
4. Explain the basic principles of the operation of diesel engine generators.		X[e]	
5. Analyze the performance of the diesel engine generator.		X[c]	
6. Analyze and test fuel injector performance.		X[c]	
7. Inspect, install, and time fuel injector pumps.		X[c]	
8. Analyze, test, and adjust mechanical and hydraulic governors.		X[c]	
9. Inspect, service, and repair the generator and exciter.		X[c]	
10. Analyze, service, and adjust the voltage regulator.		X[c]	
11. Analyze, adjust, and repair the associated control panel.		X[c]	
12. Use wiring, schematic, and "one-line" diagrams to isolate and repair defective control panel operation.		X[c]	
13. Perform preventive and corrective maintenance tests, performance checks, and adjustments of the engine generator.		X[c]	
14. Assume full maintenance responsibility.		X[f]	

[a] The maintenance concept does not explicitly cite any of the required T.O. listed.

[b] The Technician must be able to *locate* control panel components in order to function. The maintenance concept (mc) indicates no requirement to *describe* their function.

[c] Not explicitly cited.

[d] The mc does not refer to safety precautions.

[e] The mc does not require explanation of basic principles of operation.

[f] This T.O. probably relates to 2.c, "primary responsibility." But "Full" maintenance responsibility is not cited.

(Continued)

Course No. 40104

Training Outcomes Implied by the MC But Not Cited As *Training Outcomes in Catalog*

	MC Reference
1. Repair on site all failed components to maximum extent.	2.c
2. Completely overhaul equipment when necessary.	2.c
3. Select appropriate test equipment to use in maintenance.	3.a
4. Utilize test equipment correctly in maintenance.	3.a,b
5. Prepare reports on engine-generator operations.	5

(Continued)

Course No. 43410

Integrated Program for NAS En Route Automation I/O Equipment for Technicians (FPI-165)	Maintenance Concept Validated Training Outcome?		
Upon completion of this program, the trainee should be able to:	Yes	No (Why)	Unable to Determine
1. Understand IBM's Solid Logic Technology symbols, component layout, and packaging and documentation as used in the Flight Strip Printer Control Module.			X[a]
2. Understand, in block diagram form, how the IOCE, PAM, FSPCU, and FSP units are interconnected.			
3. Disassemble and reassemble parts, make mechanical adjustments, and understand operation and electrical circuitry of the 1980 Flight Strip Printer.			
4. Use the OLSA to check operation of the 1980 Flight Strip Printer.			
5. Understand the 1052 Printer-Keyboard mechanical and electrical operation.			
6. Disassemble and reassemble parts, understand operation, perform mechanical adjustments and electrical trouble shooting on the 029 Card Punch.			
7. Trace logic signals from input to output and understand logic functions of the 7289-03 Flight Strip Printer Control Module (FSPCM).			
8. Isolate malfunctions in the 7289-03 to a single component by use of the maintenance panel, indicator panels, scope and diagnostic program.			
9. Understanding 7289-03 power supply normal sequencing, recognize emergency and special power-off sequences, and use charts and interlock diagrams to isolate troubles.			
10. Locate parts and part numbers in IBM parts manuals.			
11. Understand preventive maintenance and lubrication on the 1980 Flight Strip Printer, 1052 Printer-Keyboard, and 029 Card Punch.			

[a]Lack of maintenance concept precludes validation of training outcomes.

(Continued)

Course No. 42002

Integrated Program for Automated Radar Terminal System, ARTS III for Technicians.	Maintenance Concept Validated Training Outcome?		
Upon completion of this course the trainee should be able to:	Yes	No (Why)	Unable to Determine
1. Locate and identify all subassemblies and controls.	X[a] Par. 1.3.3; 1.4		
2. Perform all maintenance checks and adjustments.		X[b] Par. 1.3.3.	
3. Recognize, analyze, localize and correct all deficiencies and malfunctions.		X[c] Par. 1.3.1; 1.3.2	
4. Evaluate effects of related equipment, i.e., those equipments interfacing with the ARTS III system.		X[d] Par. 3	
5. Analyze, interpret, and modify printouts of operational, maintenance, utility, and diagnostic programs as required.		X[e]	
6. Understand circuit, subsystem, and overall system operation of the ARTS III equipment.		X[f] Par. 2.3.1; 2.3.2	
7. Generally understand the operational program with emphasis on confidence testing and use of the operational program as a maintenance tool.		X[g]	
8. Assume full responsibility for maintenance of the ARTS III system.		X[h] Par. 3	

[a]Modules and printed circuit cards are smallest levels of equipment packaging. Subassemblies are assumed to be a larger level. Since maintenance concept (mc) requires locating modules, subassemblies containing these are also located.

[b]*All* adjustments are not performed: Par. 1.3.3 - - ". . . . all modules that can be pre-adjusted will be pre-set at the factory and depots. . . . . ."

[c]Technician is to use both hardware and software fault detector capabilities associated with the system. Hence, recognition or detection of faults in some cases will be accomplished by means other than the technician.

[d]The mc does not identify the existence of equipment interfaces with ARTS III System. Par. 3 indicates technician can be assisted by Supervisory Electronic Technician (computer) on "intersystem problems outside his area of responsibility."

[e]The mc contains no reference to "utility programs."

[f]Both field and depot repair modules and cards. It is assumed the depot will repair classes of modules and cards the field cannot. This division of labor and the presence of maintenance and diagnostic programs would argue against understanding of entire ARTS III at the circuit level.

[g]The mc contains no reference to confidence testing. There is no explicit reference to the operational program or as to how it would be used as a maintenance tool.

[h]The mc is not explicit here. Par. 3 states some assistance to be provided by Supervisory Electronic Technician.

(Continued)

Course No. 42002

Training Outcomes Implied by the MC But Not Contained in Catalog

1. Use test equipment to isolate failures not found with maintenance and diagnostic software.
2. Perform corrective maintenance in the on-line and off-line modes.
3. Perform required alignment procedures as necessary.
4. Perform system evaluation and analysis program.
5. Perform preventive maintenance.
6. Install malfunction kits.
7. Repair modules and cards
8. Prepare failure reports.

Course No. 43413

IBM-9020 Central Computer Complex	Maintenance Concept Validated Training Outcome?		
Upon completion of this course, the trainee should be able to:	Yes	No (Why)	Unable to Determine
1. Operate the IBM-9020 System both from the Element Maintenance Panels and from the System Console, configure a system and make it ready for operation, load a source program to obtain listings, and load an object program for execution.			X[a]
2. Evaluate the control paths and data paths throughout the system.			X[a]
3. Trace the operation of Read Only Storage (ROS) and in the CE and IOCE, including the ROS addressing scheme and control word generation and decoding.			X[a]
4. Trace any instructional execution through the functional units of the CE by use of CAS (microprogram documentation), data flow diagrams, and automated logic diagrams.			X[a]
5. Trace the operation and timing of Local Store, MACH store, Main Store, and Storage Protect through both fetch and store operations.			X[a]
6. Recognize and correct the conditions causing parity errors by a knowledge of the methods used for parity generation and checking within the system.			X[a]
7. Trace multiplexor and selector channel operations through both micro-program and hardware sequences.			X[a]

(Continued)

Course No. 43413 *(Continued)*

IBM-9020 Central Computer Complex	Maintenance Concept Validated Training Outcome?		
Upon completion of this course, the trainee should be able to:	Yes	No (Why)	Unable to Determine
8. Trace operation of the Peripheral Adapter Module (PAM) through addressing, priority, configuration, and interface circuits.			X[a]
9. Trace the operation of the control units which interconnect the system oriented I/O devices to the IOCE channels.			X[a]
10. Repair and perform mechanical adjustments on all system oriented I/O devices except the IBM-1052 Printer-Keyboard.			X[a]
11. Trace any of the power supply circuitry from the associated regulator through the frames to the distribution points on the gates, and trace the operation of the regulators in the Power Distribution Unit and the power sequences in all elements.			X[a]
12. Perform the appropriate electrical adjustments required for proper element timing and/or operation.			X[a]
13. Use Maintenance Diagnostic Programs, read and interpret the listings of a diagnostic section, interpret error printouts, and use the interpret Fault Locating Tests.			X[a]
14. Use special test equipment and interpret indications therefrom.			X[a]
15. Evaluate and troubleshoot the IBM-9020 as a complete system or evaluate and troubleshoot an individual element.			X[a]
16. Write, assemble, and debug programs in Basic Assembly Language, and patch and edit the Maintenance Diagnostic programs.			X[a]
17. Demonstrate a knowledge of Engineering Change Procedure and Criteria for evaluating Engineering Change Performance.			X[a]
18. Perform and evaluate wire wrap and delete operations on the IBM-9020 system.			X[a]

[a]Since a maintenance concept was not available for the equipment, it is not possible to validate the training outcomes in the catalog from that source.

(Continued)

Course No. 43413

IBM-9020 Central Computer Complex	Job Analysis Document Validated Training Outcome?		
Upon completion of this course, the trainee should be able to:	Yes	No (Why)	Unable to Determine
1. Operate the IBM-9020 System both from the Element Maintenance Panels and from the System Console, configure a system and make it ready for operation, load a source program to obtain listings, and load an object program for execution.	X[a]		
2. Evaluate the control paths and data paths throughout the system.	X[b]		
3. Trace the operation of Read Only Storage (ROS) and in the CE and IOCE, including the ROS addressing scheme and control word generation and decoding.		X[c]	
4. Trace any instruction execution through the functional units of the CE by use of CAS (micro-program documentation), data flow diagrams, and automated logic diagrams.		X[c]	
5. Trace the operation and timing of Local Store, MACH Store, Main Store, and Storage Protect through both fetch and store operations.		X[c]	
6. Recognize and correct the conditions causing parity errors by a knowledge of the methods used for parity generation and checking within the system.		X[d]	
7. Trace multiplexor and selector channel operations through both micro-program and hardware sequences.		X[e]	
8. Trace operation of the Peripheral Adapter Module (PAM) through addressing priority, configuration, and interface circuits.		X[c]	
9. Trace the operation of the control units which interconnect the system oriented I/O devices to the IOCE channels.		X[c]	
10. Repair and perform mechanical adjustments on all system oriented I/O devices except the IBM-1052 Printer-Keyboard.	X[f]		
11. Trace any of the power supply circuitry from the associated regulator through the frames to the distribution points on the gates, and trace the operation of the regulators in the Power Distribution Unit and the power sequences in all elements.		X[c]	

(Continued)

Course No. 43413 *(Continued)*

IBM-9020 Central Computer Complex	Job Analysis Document Validated Training Outcome?		
Upon completion of this course, the trainee should be able to:	Yes	No (Why)	Unable to Determine
12. Perform the appropriate electrical adjustments required for proper element timing and/or operation.	X[g]		
13. Use Maintenance Diagnostic Programs, read and interpret the listings of a diagnostic section, interpret error printouts, and use the interpret Fault Locating Tests.	X[h]		
14. Use special test equipment and interpret indications therefrom.	X[i]		
15. Evaluate and troubleshoot the IBM-9020 as a complete system or evaluate and troubleshoot an individual element.	X[j]		
16. Write, assemble, and debug programs in Basic Assembly Language and patch and edit the Maintenance Diagnostic programs.	X[k]		
17. Demonstrate a knowledge of Engineering Change Procedure and Criteria for evaluating Engineering Change Performance.	X[l]		
18. Perform and evaluate wire wrap and delete operations on the IBM-9020 system.	X[m]		

[a]Yes, see page 1-2, par. 1, and 1-3, par. 2.
[b]Yes, see page 1-2, par. 1, and 1-3, par. 2.
[c]No stated requirement to "trace".
[d]Not explicitly identified as a duty.
[e]See note 3; page 6-5, par. 8 relates to multiplexor.
[f]Yes, see for example page 10-2, Card Reader/Punch-Punch 1.
[g]Yes, see for example page 7-3, (PAM) par. 2.
[h]Yes, see for example page 1-3, par. 1, 2.
[i]Yes, see for example page 5-2, par. 1.
[j]Yes, see for example page 1-2, par. 1, 2.
[k]Yes, see for example page 12-6, par. 1, 2.
[l]Yes, see for example page 1-3, par. 3.
[m]Yes, see for example page 1-3, par. 3.

(Continued)

FAA Course Catalog No. 43413

Training Outcomes Implied by Job Analysis Document Not Included As Catalog Training Outcomes

		Job Analysis Reference Page	Paragraph
1.	Perform 9020 System certification.	1-2	1
2.	Isolate system malfunctions to subsystem level.	2-3	1
3.	Load and execute maintenance diagnostic programs for system, SE, PAM, and ICU.	1-2 5-3 7-3 9-3	1 3 3 2
4.	Load and execute FLT.	1-3	2
5.	Read and interpret SCOPEX and LADS.	1-3	2
6.	Perform engineering changes to system and to CE and IOCE.	1-3 4-4 6-5	3 7 7
7.	Analyze and evaluate main control panel indicators for all major elements.	1-4	4
8.	Analyze and evaluate System Interface sequencing data transfer, priority and control between major elements and IO units.	1-4	5
9.	Analyze and evaluate log-outs and dumps.	2-4	7
10.	Isolate SC malfunctions to component level.	3-3	1
11.	Check SC data transfer to IO devices and PAM.	3-3 7-3	2 2
12.	Analyze, evaluate, and repair power supplies to component level in CE, SE, IOCE, PAM, TCU/TD and ICU.	4-3 5-3 6-4 7-2 8-5 9-2	1 4 1 1 5 1
13.	Check and adjust metering circuits in CE and IOCE.	4-3 6-4	2 2
14.	Select and activate "ROS" routines to evaluate CE and IOCE performance.	4-3 6-4	3 3
15.	Use manual, CAS, ALD and test equipment to isolate malfunctions in CE and IOCE.	4-3 6-4	3 3
16.	Check temperatures in CE and IOCE.	4-3 6-4	4 4
17.	Perform timing tests in CE, SE, and IOCE.	4-4 5-2 6-4	5 1 5
18.	Check and adjust ferrite core operating voltage.	5-2	2

(Continued)

FAA Course Catalog No. 43413 *(Continued)*

		Job Analysis Reference	
		Page	Paragraph
19.	Use I/O microprogram to analyze operation of multiplexor, selector and common channel.	6-5	8
20.	Inspect, clean, lubricate, adjust mechanical components in TCU/TD.	8-4	1
21.	Measure tape motion and IRG.	8-5	7
22.	Measure compatibility of two or more tape units.	8-5	8
23.	Align and adjust mechanical components of Card/Reader, Punch.	10-1 10-2	
24.	Use HSP diagnostic programs for evaluation.	11-2	1
25.	Isolate HSP faults to single circuit malfunction.	11-3	3
26.	Perform scheduled preventive maintenance on HSP.	11-3	4
27.	Create machine language programs for operation and diagnosis.	12-6	1
28.	Recommend improvements, recognize and report deficiencies in maintenance and diagnostic programs.	12-7	3

(Continued)

Course No. 40318

Integrated Program for ATCBI-3 Transmitter/Indicator Site	Maintenance Concept Validated Training Outcome?		
Upon completion of this course, the trainee should be able to:	Yes	No (Why)	Unable to Determine
1. Install system units, make proper wiring interconnections, and insure correct coaxial cable termination.			X[a]
2. Completely align all parts of the system for optimum performance.			X[a]
3. Recognize and analyze performance deficiencies to isolate the unit or units creating the problem.			X[a]
4. Correct deficiencies by adjustment or alignment of any unit using approved procedures.			X[a]
5. Isolate circuit faults to individual components.			X[a]
6. Repair circuit malfunctions or faults in any unit of the system.			X[a]
7. Make changes in system patching and connections to meet all requirements of reconfiguration.			X[a]
8. Use general and special purpose test equipment to analyze system performance and to isolate faults. Check calibration and determine the accuracy of all test equipment.			X[a]
9. Train operations personnel in the correct operational use of controls that affect system performance.			X[a]
10. Conduct brief training sessions for other maintenance personnel.			X[a]

[a]Since a maintenance concept was not available for the equipment it is impossible to validate training outcomes in the catalog on that basis.

(Continued)

Course No. 40318

Integrated Program for ATCBI-3 Transmitter/Indicator Site	Job Analysis Document Validated Training Outcome?		
Upon completion of this course, the trainee should be able to:	Yes	No (Why)	Unable to Determine
1. Install system units, make proper wiring interconnections, and insure correct coaxial cable termination.		X[a]	
2. Completely align all parts of the system for optimum performance.		X[b]	
3. Recognize and analyze performance deficiencies to isolate the unit or units creating the problem.		X[c]	
4. Correct deficiencies by adjustment or alignment of any unit using approved procedures.		X[d]	
5. Isolate circuit faults to individual components.	X[e]		
6. Repair circuit malfunctions or faults in any unit of the system.	X[f]		
7. Make changes in system patching and connections to meet all requirements of reconfiguration.		X[g]	
8. Use general and special purpose test equipment to analyze system performance and to isolate faults. Check calibration and determine the accuracy of all test equipment.	X[h]		
9. Train operations personnel in the correct operational use of controls that affect system performance.	X[i]		
10. Conduct brief training sessions for other maintenance personnel.		X[j]	

[a]No reference to installation is contained in Job Analysis document.
[b]No reference is made to alignment of system as a whole.
[c]No explicit reference made to isolation to unit causing trouble.
[d]Monitor (duty 9) tasks do not include adjustment or alignment.
[e]Job analysis document repeatedly asserts this, except for duty 43 test equipment; duty 46 engine generator; and duty 48 buildings.
[f]Yes, even to emergency repair of building.
[g]"Reconfiguration" is not explicitly stated.
[h]Yes, see, for example, duty 23, and duty 43 test equipment.
[i]Yes, see duty 39.
[j]There is no reference made to this requirement in the job analysis document.

(Continued)

Course No. 40318

Training Outcomes Implied by Job Analysis Document Not Included As Catalog Training Outcomes

	Job Analysis Reference Duty No.
1. Inspect buildings	48
2. Service engine generator	46
3. Service equipment rack motors	45
4. Maintain records	44
5. Perform facility evaluation and certification following aircraft accident	40
6. Perform facility certification	38
7. Perform flight inspections	35

CONCLUSIONS

Since only three maintenance concepts were supplied for the eight equipment-oriented training programs, and one of these was not relevant to the equipment to be maintained, it is obvious that maintenance concepts have not been routinely prepared. Even within the three supplied, there are significant differences in level of detail and scope of coverage. As presentlys structured, maintenance concepts ought not to be used as the sole source for determining training outcomes.

TRAINING COURSE LENGTH

OBJECTIVE

The objective of this phase was to review the length of each of the 10 courses in comparison to the lengths expected from an examination of required training outcomes.

METHOD

Required training outcomes are those which are listed in the Academy Catalog and which were found to be valid through a study of the Maintenance Concepts provided. For some courses, a Job Analysis document was used in lieu of a Maintenance Concept when the latter did not exist. For other courses, neither a maintenance concept nor a job analysis document was available. Training outcomes could

not be validated for such courses, and no conclusion with respect to length can be drawn based upon consideration of valid training outcomes and attention paid to them by course content. The following four courses fall into this category:

(1) Course No. 43411, I/O for Technicians
(2) Course No. 40216, Wilcox Mark I ILS
(3) Course No. 40200, Rho-Theta Principles
(4) Course No. 40115, Solid State Fundamentals

The following two courses had maintenance concepts:

(1) Course No. 40104, Diesel Engine Generator
(2) Course No. 42002, ARTS III

The following courses had Job Analysis documents:

(1) Course No. 40001, Communications Equipment
(2) Course No. 40210, VHF/UHF DF
(3) Course No. 40318, ATCBI-3
(4) Course No. 43413, IBM-9020 CCC

Course Control Documents, Instructor Guides, and Lesson Plans for the 10 courses were collected and examined. For each valid training outcome, the course materials were examined to find content which was related to it. When a reference to an outcome was located within an Instructor's Guide, for example, a notation was made of the number of hours devoted to that lesson. Since Instructor Guides rarely indicate any finer division of time than the whole amount for the lesson, it was impossible to determine the exact percentage of that time to be allocated to the training outcome referenced. Thus, the times indicated are actually the number of lesson-hours which contain some portion of content related to training outcome.

Once all the Instructor Guides for a given course had been reviewed for identification of content related to a specific training outcome, they were reviewed again for the next specific training outcome. This process was continued, entailing as many reviews as there were valid training outcomes. Then the total hours of lessons containing valid training outcome content were summarized and are reported with the outcomes in the tabulated data to follow.

Additional data on course length were derived from on-site observation of the conduct of training during the observation period. These data are quite specific in that they refer to particular instances where, in the judgment of the observer, changes in course length may be effected. The observations were made at a particular point in time and of particular presentations. The extent to which such observations could be generalized to similar lessons within a particular course can be determined only through an in-depth study of the course as part of a re-engineering effort, which is clearly beyond the scope of the present study. The observations referenced are described in a later section on Instructional Observation.

RESULTS

The number of lesson-hours found to be devoted to accomplishing specific valid training outcomes is listed with the outcome in Table 3.

A number of general statements can be made with respect to course length.

(1) Of the six courses that had either maintenance concepts or job analysis documents, five were found to have some valid training outcomes. Four of these courses had Job Analysis documents, the other a maintenance concept. For the four courses that had job analysis documents, three were found to devote some time to valid training outcomes. In the case of the remaining such course (43413), it was impossible to determine the time allocation to valid training outcomes, since the

lesson plans or guides generally did not specify the number of hours to be spent in presenting the topic. The latter comment also applies to course No. 42002 which had a Maintenance Concept and valid training outcomes.

Table 3

COURSE LENGTH ANALYSIS

Course No. 40001, Communications Equipment

(No maintenance concept available. Job Analysis document for the Remote Center Air Ground and Remote Transmitter/Receiver Facilities were used as the source to validate training outcomes.)

Total Course Instructional Hours: 480.

Training Outcomes Validated by Job Analysis Document	Lesson-Hours
5. Analyze, service, and check performance of FAA communications receivers.	34.5
6. Analyze, tune, and load FAA communications type transmitters.	47
Training Outcomes Implied by Job Analysis Document	
1. Perform system evaluation in connection with flight inspection.	2
2. Perform system evaluation (Sector).	0
3. Certify system.	28
4. Train ATM personnel in operation.	0
5. Perform system evaluation and certification in connection with aircraft accident.	0
6. Perform equipment modifications.	0
7. Evaluate test equipment.	0
8. Maintain records.	2
9. Service rack motors.	0
10. Service engine generator.	0
11. Inspect A.C. supply voltage regulators.	0
12. Inspect buildings.	0

Course No. 40210, VHF/UHF DF

(No maintenance concept available. Two job analysis documents which were not for the Doppler DF of the course were used as sources to validate training outcomes.)

Total Course Instructional Hours: 80.

Training Outcomes Validated by Job Analysis Documents	Lesson-Hours
2. Evaluate the operation and performance of the equipment.	5
3. Diagnose and correct equipment malfunctions.	13

(Continued)

Course No. 40210, VHF/UHF DF *(Continued)*

Training Outcomes Validated by Job Analysis Documents	Lesson-Hours
4. Perform all maintenance checks and adjustments in accordance with current operating standards.	20
6. Properly use all facility test equipment.	6

Training Outcomes Implied by Job Analysis Documents	
1. Certify normal operation of system.	0
2. Evaluate and certify facility in connection with aircraft accident.	0
3. Perform equipment modifications.	0
4. Maintain proper records of facility operation and performance.	0
5. Service building and equipment rack motors.	0
6. Service engine generator.	0
7. Inspect condition and operation of AC supply voltage regulators.	0
8. Inspect condition of building and antenna shelter.	0

Course No. 40104, Diesel Engine Generators

(The maintenance concept supplied was entitled "Maintenance Concepts for Standby Engine Generators.")

Total Course Instructional Hours: 120

Training Outcomes Validated by Maintenance Concept

(No training outcomes were found to be valid from analysis of the maintenance concept.)

Training Outcomes Implied by Maintenance Concept	Lesson-Hours
1. Repair on site all failed components to maximum extent.	([a])
2. Completely overhaul equipment when necessary.	0
3. Select appropriate test equipment to use in maintenance.	2
4. Utilize test equipment correctly in maintenance.	4
5. Prepare reports on engine-generator operations.	0

[a]Control panels troubleshooting lab (unspecified duration, but probably 4 hours) consisting of solving instructor-induced troubles consisting of lead removals. No practice in repair.

(Instructor guides consist of daily topic outlines.)

(Continued)

Course No. 42002, ARTS III

(The maintenance concept against which the training outcomes were validated is entitled "Federal Aviation Administration Maintenance Concept for ARTS III Automated Terminal Radar System," dated 24 April 1970.)

Total Course Instructional Hours: 720

Training Outcomes Validated by Maintenance Concept	Lesson-Hours
1. Locate and identify all subassemblies and controls.	([a])

[a]The Instructor Guides for the ARTS III course supplied do not indicate time allocations to lessons. References were made to location of console controls, location of maintenance indicators and switches of DAS. No Instructor Guide could be found explicitly devoted to identification of subassemblies.

Training Outcomes Implied by Maintenance Concept	Lesson-Hours
1. Use test equipment to isolate failures not found with maintenance and diagnostic software.	([b])
2. Perform corrective maintenance in the on-line and off-line modes.	([c])
3. Perform required alignment procedures as necessary.	([d])
4. Perform system evaluation and analysis program.	0
5. Perform preventive maintenance.	0
6. Install modification kits.	0
7. Repair modules and cards.	0
8. Prepare failure reports.	0

[b]Test equipment usage is referenced in laboratories, but no time given.
[c]A discussion of maintenance and diagnostic tests is given under maintenance philosophy, but no times.
[d]Alignment procedures are referenced in laboratories, but no time allocated.

Course No. 40318, ATCBI-3

(No maintenance concept available. Job analysis document for SECRA was used as source to validate training outcomes.)

Total Course Instructional Hours (Resident): 160

Training Outcomes Validated by Job Analysis Document	Lesson-Hours
5. Isolate circuit faults to individual components.	58
6. Repair circuit malfunctions or faults in any unit of the system.	56[a]

[a]Lesson plans or Instructor Guides do not indicate exact character of "repair." Lessons on troubleshooting imply students are required to isolate troubles, but there is no evidence found that they restore equipment to operational status. Typical problems inserted include: removing tubes, inserting tubes with missing pins, removing transistors, opening CRs, and relay problems. No resistor or capacitor problems are used.

(Continued)

Course No. 40318, ATCBI-3 *(Continued)*

Training Outcomes Validated by Job Analysis Document	Lesson-Hours
8. Use general and special purpose test equipment to analyze system performance and to isolate faults. Check calibration and determine the accuracy of all test equipment.	23
9. Train operations personnel in the correct operational use of controls that affect system performance.	0

Training Outcomes Implied by Job Analysis Document	
1. Inspect buildings.	0
2. Service engine generator.	0
3. Service equipment rack motors.	0
4. Maintain records.	0
5. Perform facility evaluation and certification following aircraft accident.	0
6. Perform facility certification.	0
7. Perform flight inspections.	0

Course No. 43413, IBM-9020 CCC

(No maintenance concept available. A job analysis document was used as a source to validate training outcomes.)

Total Course Instructional Hours: 1440.

Training Outcomes Validated by Job Analysis Document	Lesson-Hours
11. Operate the IBM-9020 System both from the Element Maintenance Panels and from the System Console, configure a system and make it ready for operation, load a source program to obtain listings, and load an object program for execution.	([a])
2. Evaluate the control paths and data paths throughout the system.	
10. Repair and perform mechanical adjustments on all system-oriented I/O devices except the IBM-1052 Printer-Keyboard.	
12. Perform the appropriate electrical adjustments required for proper element timing and/or operation.	

[a]The majority of lesson plans or guides do not specify the number of hours to be spent in presenting the lesson. Consequently, even when content could be identified as relating to, or in support of, valid training outcomes, there was no way to quantify the finding. Many lesson plans do not identify the objective of the training to be accomplished. In cases where the objectives were identified, they were not stated with sufficient behavioral specificity to be relatable to any training outcome required. Even though it was not possible to determine the amount of time spent training toward a given training outcome, it was possible to determine that nearly all of the valid training outcomes did have some training directed toward them.

(Continued)

Course No. 43413, IBM-9020 CCC *(Continued)*

Training Outcomes Validated by Job Analysis Document — Lesson-Hours

13. Use Maintenance Diagnostic Programs, read and interpret the listings of a diagnostic section, interpret error printouts, and use the interpret Fault Locating Tests.
14. Use special test equipment and interpret indications therefrom.
15. Evaluate and troubleshoot the IBM-9020 as a complete system or evaluate and troubleshoot an individual element.
16. Write, assemble, and debug programs in Basic Assembly Language and patch and edit the Maintenance Diagnostic programs.
17. Demonstrate a knowledge of Engineering Change Procedure and Criteria for evaluating Engineering Change Performance.
18. Perform and evaluate wire wrap and delete operations on the IBM-9020 System.

(2) In equipment-oriented courses for which adequate student guides have been prepared, course length could be materially reduced by reducing the time devoted to the presentation of detailed theory of operation of the equipment. This could be done by permitting the instructor to describe circuit operation at a grosser level than is now the case, depending upon the student guides to carry the detail.

(3) Some laboratory exercises are actually demonstrations. They could be videotaped, filmed, or put into another format with consequent reduction in laboratory time, and release of equipment.

DISCUSSION

Examination of the Course Length Analysis sheets for each of the courses reveals that there is a great disparity between the number of hours allocated to the conduct of the resident course and the number of hours found to be devoted to topics related to valid training outcomes. For example, in Course No. 40210, VHF/UHF DF, the resident program is 80 hours in duration. The analysis indicates that 44 lesson-hours are devoted to training in those outcomes found to be valid through analysis of the Job Analysis document.

One should not conclude from this that the course is 36 hours too long. It should be remembered that the Instructor Guides do not indicate any finer breakdown of time allocated to topic than for the entire lesson. Thus, only a portion of that lesson may be devoted to content related to a valid training outcome. On the other hand, it is entirely possible that some lessons contain elements or portions relating to valid training outcomes which were undetected because of the general lack of detail with which Instructor Guides are written. The extent of the apparent disparity may be far smaller than observed. The lack of supportive documentation precludes establishing a reliable estimate of course-length excesses.

Training outcomes implied by the job analysis document, or maintenance concept, which have not been identified previously as training outcomes in the course catalog, would result in minor increases in some course lengths if the outcomes were adopted.

Still another factor must be considered in connection with course length. This is the existence of content based upon training outcomes which were found not to be valid. In the DF course, for example, one training outcome is: "Upon completion of this course, the trainee should be able to: 1. Explain the complete theory of operation." There is ample evidence, both from a study of the course materials and from direct observation, that an explanation of the theory of operation is presented to the trainee. It is questionable whether in training he is ever required to demonstrate his ability to *explain* the theory of operation, but more importantly a study of the Job Analysis document fails to indicate that the job requires him to do so.

Technically, if training is to be conducted in those content areas related to valid training outcomes, the DF course is too long by the amount of time devoted to training the student to be able to *explain* the complete theory of operation, since that training outcome is not valid. Removal of such content is justifiable on the basis that ability to *explain* is not supported by the Job Analysis document. However, teaching theory of operation may well be justified on the basis that knowledge of the theory of operation supports another valid training outcome, such as "diagnose and correct equipment malfunctions." To make that determination, a task/skill and knowledge analysis must be performed for the Doppler DF taught in the course. If it is then found that knowledge of the theory of operation supports a valid training outcome, it may be justifiably included as content.

Manner of Presentation

The manner in which content is presented also has a bearing on course length. For example, in the ATCBI-3 course, approximately 86% of the lectures appear to be devoted to a description of the theory of operation of the equipment. Direct observation of the presentation of lecture material confirmed that the instructor would describe how signals were routed through circuits in detail. Virtually the entire lesson would be devoted to this activity. Few, if any, questions were raised by students, and few questions put to them by the instructor.

Examination of the student texts for this course (FR-527-1,[1] for example) reveals that it consists predominantly of explanations of how the circuits work, or theory of operation of the equipment. Since the attempt has already been made to incorporate an adequate description of the theory of operation in the student guides, and the guides are retained by the students on departure from the Academy, the desirability of presenting that material in lecture form is questionable. That is not to say that the instructor presents student guide material verbatim, but he does address the content in much the same manner as the student guide.

Students have been characterized as mature, responsible, dedicated professionals who view their Academy training both as providing the means by which immediate job goals can be achieved and as furthering their long-term career development. It seems reasonable to assume that they will apply themselves to mastering course content after a day's formal training is concluded, even when not directed to do so. If this is true, it may well be possible to let the student guides carry the burden of explaining the detailed theory of operation, permitting the instructor to concentrate on presenting the theory in much grosser levels, with an attendant reduction in amount of time devoted to lectures on essentially redundant material. For those courses where the student guides are judged adequate to the task, a 50% reduction in lecture time currently devoted to presenting detailed theory of operation would not be an unreasonable target.

[1] **Federal Aviation Administration,** ***ATC Radar Beacon Interrogater ATCBI-3 Theory of Operation,*** **Manual FR 527-1, December 1970.**

This discussion, of course, assumes that the presentation of theory of operation as it is presently structured, either in text or lecture, can be supported by a job requirement, that it is important knowledge required to perform effectively. Present circuit operation is described in the normal mode, that is, without troubles. The rationale for this approach might be that once the technician knows how the circuits operate normally, he is in a position to deduce the nature of the trouble when the circuits operate abnormally. The difficulty with this approach is that it requires the technician to recall as much as he can about normal circuit operation when faced with abnormal operation. Each technician must develop and test his own troubleshooting ideas.

A more maintenance-oriented approach to the teaching of circuit theory would be to incorporate content relating to abnormal operation within the same lesson on normal operation. In this way, the trainee would have an immediate opportunity to practice using what he has just learned about normal operation in the solution of problems of abnormal operation. From an examination of Instructor Guides, and from direct observation, there is no indication that such a method is employed. The impact upon training time length would depend upon the effect of the reorientation of the courses to emphasize trouble shooting.

Laboratory Work

Laboratory exercises should complement the lectures. They should occur as close to the lecture in time as scheduling will permit. They should permit the trainee to apply the knowledges he has acquired in the lecture, and develop the skills which the knowledges enable. The intent to adhere to these principles is clearly evident. Whenever possible, laboratories are scheduled for the afternoon session and are on topics which were discussed in lecture earlier that day. In some cases, however, solid state fundamentals students were permitted to perform several different experiments. There was no equipment shortage which might have accounted for this practice. The reason given was that some students work more slowly than others. Permitting students to work at their own pace can be a useful training method if properly applied. In this case, it is likely that the time lapse between content presentation in lecture, and accomplishment of the related experiment was excessive for some students.

In another instance, it was clear that what purported to be a laboratory exercise was in reality a demonstration. This particular exercise (see ARTS III, Instructional Observation details, Appendix A) could be filmed, video-taped, or conducted on a paper or hardware mockup, and presented to the class as a whole, and would consume one-fourth the time presently devoted to the subject.

In still another case, students practiced what amounted to a straight procedural task on the IBM 9020 system console maintenance panel. This procedural task could have been learned without access to the computer, releasing it for more pressing needs.

These findings were made from direct observation of the laboratory exercises. In summary, they indicate that means other than the hardware would suffice to accomplish the purpose to which the hardware was put in some cases. They do not indicate that there are always suitable alternatives to the hardware, or superior methods to use.

Use of Academy Equipment

One reason advanced in support of Academy-conducted equipment-oriented training is that it affords the trainee the opportunity to perform certain actions on

the school's equipment which he would be prevented from doing on equipment installed in an operational setting. The reason is that equipment installed on site is required for an operational mission; if it is not in use, it is on standby, or undergoing maintenance. In any event it is not available for use by the technician to learn on, or to test his ideas on the causes of malfunctions. To permit him to do so might impair the operational availability or even induce an unnecessary failure.

To some extent, equipment at the Academy is treated with similar protectiveness, but for somewhat different reasons. The equipment is needed for training; therefore any troubles inserted into the equipment, however inadvertently by the trainee, would have to be removed before the equipment was available for the next usage. However, trainees do have a greater opportunity to learn with Academy equipment than with operational equipment. For much the same reason, instructors are likely to select trouble-shooting problems which could not cause additional troubles (multiple malfunction type), which are easy (take little time) to install and remove, but which for these very reasons may not adequately reflect field experience.

SUMMARY

Does the finding that time devoted to valid training outcomes constitutes only 6.7% mean that the courses contain 93.3% irrelevant materials which should summarily be eliminated from the program? Emphatically no! It merely indicates that the documentation available does not support the training outcomes. Neither maintenance concepts nor job analysis documents supplied contain the detail or level of specificity required to establish measurable training objectives. Without a clear specification of the tasks to be performed by the technician on the job, the training required cannot be specified. Once the tasks have been identified, the standards of task performance may be set. Then decisions as to the degree of task mastery can be made with respect to methods of instruction. Should the task be taught in a resident course, or OJT? Is complete mastery required in resident training, or will some lower level be adequate? Once tasks are identified, skills and knowledges supporting the accomplishment of the tasks would have to be identified.

It is only after all of this preliminary groundwork has been completed that course length can rationally be addressed. It is, after all, the performance capability of the technician which is being developed in the training process. The training, therefore, should take as long or as short a time as required to develop performance to some specified standard. In the absence of information on either the tasks to be performed or the standards required, course lengths cannot be meaningfully managed.

UTILIZATION OF TRAINING METHODS AND MEDIA

OBJECTIVE

The objective of this phase was to study the use of training methods and media for their impact on course length.

METHOD

Course materials were reviewed for the purpose of determining the methods and media used in presentation of instruction, both from the standpoint of indicated usage and from the standpoint of availability.

Two data sources were utilized in performing this objective: Instructor Guides/ Lesson Plans and listings of training aids/devices available. For a given course, the lesson plans were examined to detect the presence and number of instances of usage of training media, such as Vugraphs. The total number of instances of usage of the medium were then recorded and compared with the number of the corresponding type of medium indicated available in the list of training aids/devices for the course. The number of hours devoted to a method of instruction (lecture/lab/problem solving) was obtained from course control documents, and also recorded. These data were then accumulated for all courses and appear in Table 4.

DISCUSSION

For some Lesson Plans/Instructor Guides specific identification of the media was made. For example, in the I/O course a Vugraph might be identified as Vugraph 2-59. Identification of media in this form made it possible to obtain a total of the instances of Vugraph usages. On the other hand, there were numerous instances where Vugraphs were called for by no other identification than "Vugraphs." In such cases it was impossible to determine a numerical value for instances of usage.

There were also situations in which the number of medium utilizations exceeded the number of such items available. The most probable explanation is multiple uses of the same item (Vugraph 2-59, for example.)

In Course No. 40104, for example, only 35 instances of Vugraph usage were found, but 265 Vugraphs were reported available. While this may be viewed as under-utilization of existing media, the degree of under-utilization may not be as severe as it appears. It is possible that the number reported available consists of multiple sets.

It is clear from an examination of the data in Table 4 that the dominant method of presentation is the lecture (including Student-Centered materials), with laboratories next. Taking the 10 courses as a whole, about 62% of the resident course time is devoted to presenting instruction via the lecture method. Approximately 33% is devoted to laboratories, and about 5% devoted to "problem solving."

The dominant medium utilized was that of the Vugraph. (Chalkboard usage is so pervasive that no attempt was made to indicate its usage.) The only other medium with significant usage was 35mm slides, and here the only enumerable usages occurred in one course, No. 40115.

The selection of the best medium to use in presenting instruction depends on the instruction to be presented. When student outcomes, based on job requirements have been determined, the content can be generated to obtain them. It is only then that the selection of the most effective medium of presentation can be made, but even then the contribution to improved training by selecting the most effective medium is small in comparison to the identification of relevant content. Decisions are most frequently made on the basis of cost, since, for the most part, differential effectiveness of the medium is small.

Table 4

Utilization of Training Methods and Media

Course No.	Short Title	Method			Media									
		Course Length (Hrs)			Vugraph		Film		TV Film		35mm Slides		Audio Tape	
		Lecture	Lab.	Prob. Solv.	Usage	Avail	Usage	Avail	Usage	Avail	Usage	Avail	Usage	Avail
40001	CE	171	149		*	175	0	0	0	0	0	0	0	0
40225	DF	40	40		*	72	0	0	0	0	0	0	0	0
40104	DEG	35	85		35	265	0	0	1	**	0	0	0	0
40115	SSF	40	40		111	121	0	0	0	0	227	204***	0	0
40200	TACAN	151	56	107	*	422	1	2	0	0	0	0	0	0
40216	Wilcox	100	100		****	138	****	2	0	0	0	0	0	0
42002	ARTS III	576	72	72	*	77	0	0	0	0	*	49	*	1
40318	ATCBI-3	70	50		*	20	0	0	0	0	0	0	0	0
43411	I/O	122	118		555	100***	*	2	0	0	*	50	0	0
43413	9020	960	480		80	370	1	1	0	0	0	0	0	0

* Unspecified: Instructor Guides either failed to identify item or indicated type without quantity.

** List of Training Aids for course did not include TV film.

*** Number available can be less than number used because of multiple usages of available item.

**** Instructor Guides/Lesson plans were not available for Wilcox.

TOPIC DUPLICATION AMONG ANF RESIDENT TRAINING COURSES

OBJECTIVES

The purpose of this phase was to estimate the degree of duplication of topics among major training program areas.

In order to effectively identify duplicate topics between ANF resident courses, the various sequences of courses taken by FAA maintenance personnel must be determined. Currently, there are more than 70 resident training courses conducted (or soon to be conducted) for personnel in five different career fields. At present the FAA does not have any official policy which defines personnel career progression patterns for certification on more than one equipment system. Furthermore, discussions with representatives[1] of the Manpower Training and Budget office revealed that there is not any policy, managed at Headquarters level, governing the progression of personnel across career fields.

In the absence of any official policy dictating preferred career progression paths, and the seemingly infinite permutations of permissible paths across career fields, the major effort with respect to topic duplication was placed on that occurring *within* career fields, with only a quick look at the topic duplication across career fields with respect to two courses (Radar & Navaids) which were the major interface between the career fields.

METHOD

To determine the extent of topic duplication, it was necessary to impose a structure on this situation and make certain assumptions. A series of charts (Figures 1-5) were developed depicting the sequence of resident training courses leading to certification and which personnel could follow in the various career fields. Training paths (Figures 6-10) were established for the 10 courses and were based upon prerequisite training information specified in the FAA Catalog of Training Courses. The single exception to this involves the Diesel Engine Generator Course. In this instance, the training plan currently pending approval was used to identify the prerequisite training.

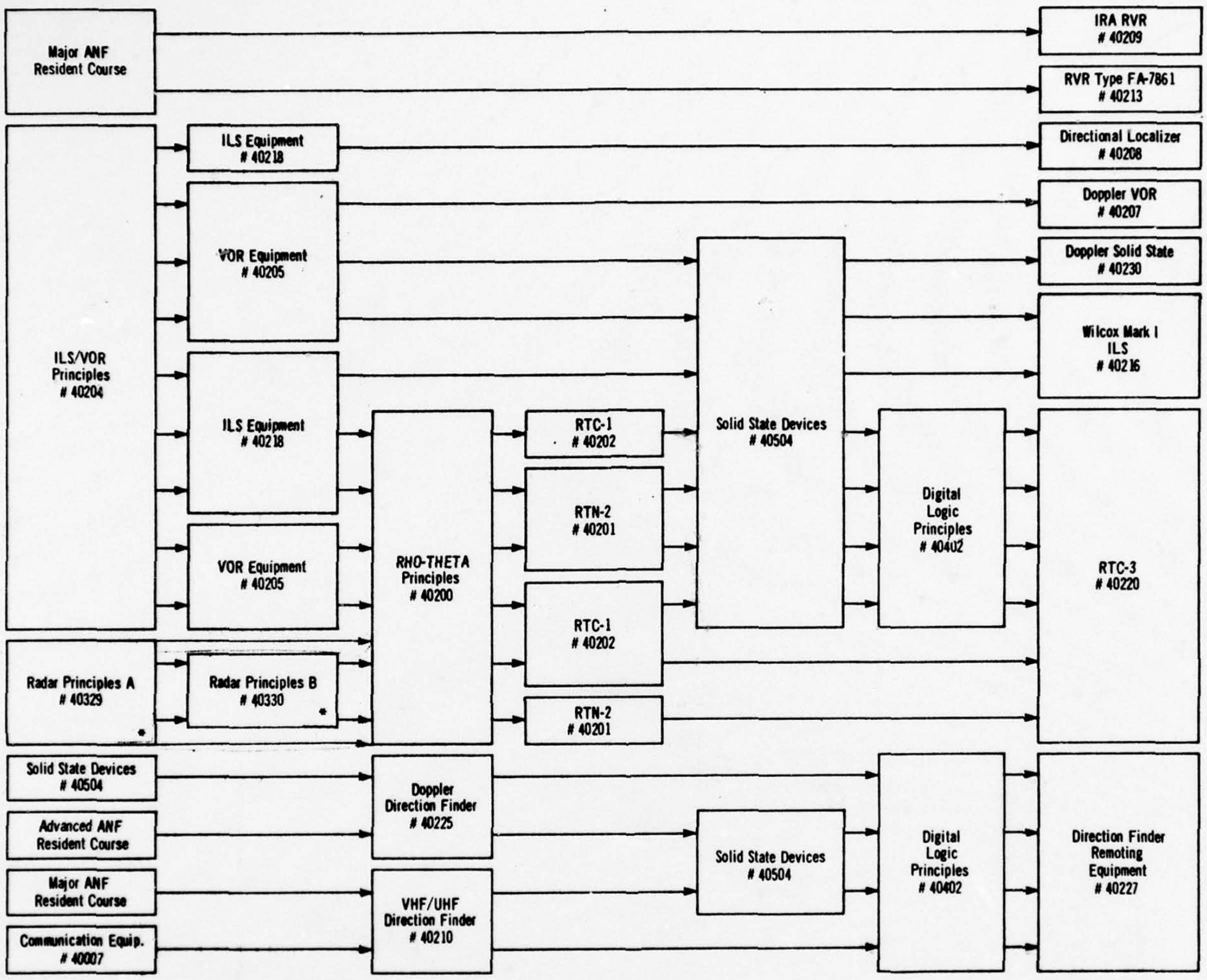
The resident training courses shown in the Figures include both those which are part of an integrated program and those pending final approval.

In those instances where the catalog listed a course not currently being taught, the successor course was substituted. For example, if the catalog listed Radar Principles (40300) as a prerequisite, the present-day Radar Principles A and B courses were substituted. The other major instances of this involved the old Data Processing Principles, Phase I Course (40400) which was replaced by Digital Logic Principles (40402) and Transistor Electronics (40503) which was replaced by Solid State Devices (40504). Since the examination of content duplication is limited to resident training, the figures do not contain directed study courses, OJT courses, prerequisite validation examinations, or certification examinations which could be an acceptable substitute to a resident course as a prerequisite for a given course.

Data sources used in determining the degree of topic duplication consisted primarily of course outlines for the 10 courses. In addition to course outlines, Lesson Plans and training manuals were used when necessary and available. The method consisted of selecting one course outline in the training path of one of the 10 courses and comparing it to each of the other outlines for courses in that training path. The comparison was made by searching the second outline for a topic which appeared in the first outline. If

[1] Memorandum, FAA Technician Career Progression Patterns, dated 2 August 1971 (Appendix B).

Navigational Aids Career Field



*Acceptable substitute prerequisites.

Figure 1

Communications Career Field

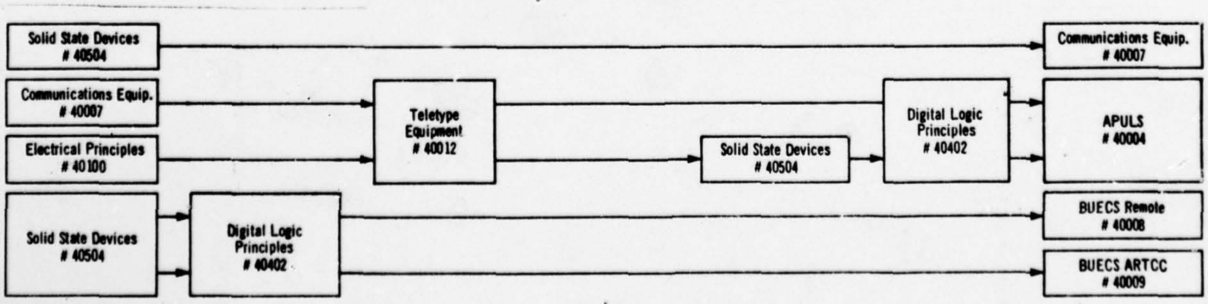


Figure 2

Radar Career Field

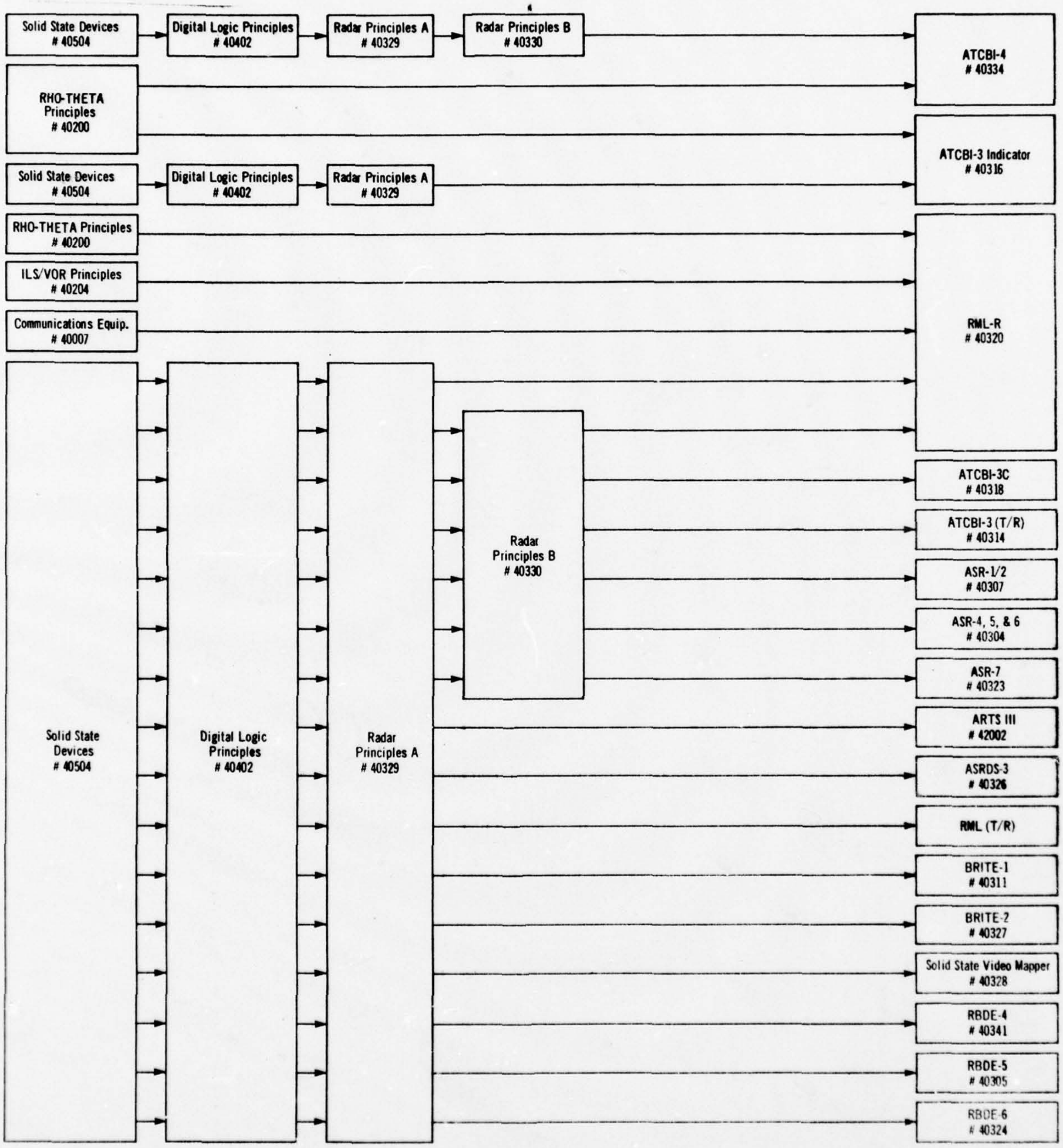


Figure 3

Data Processing Career Field

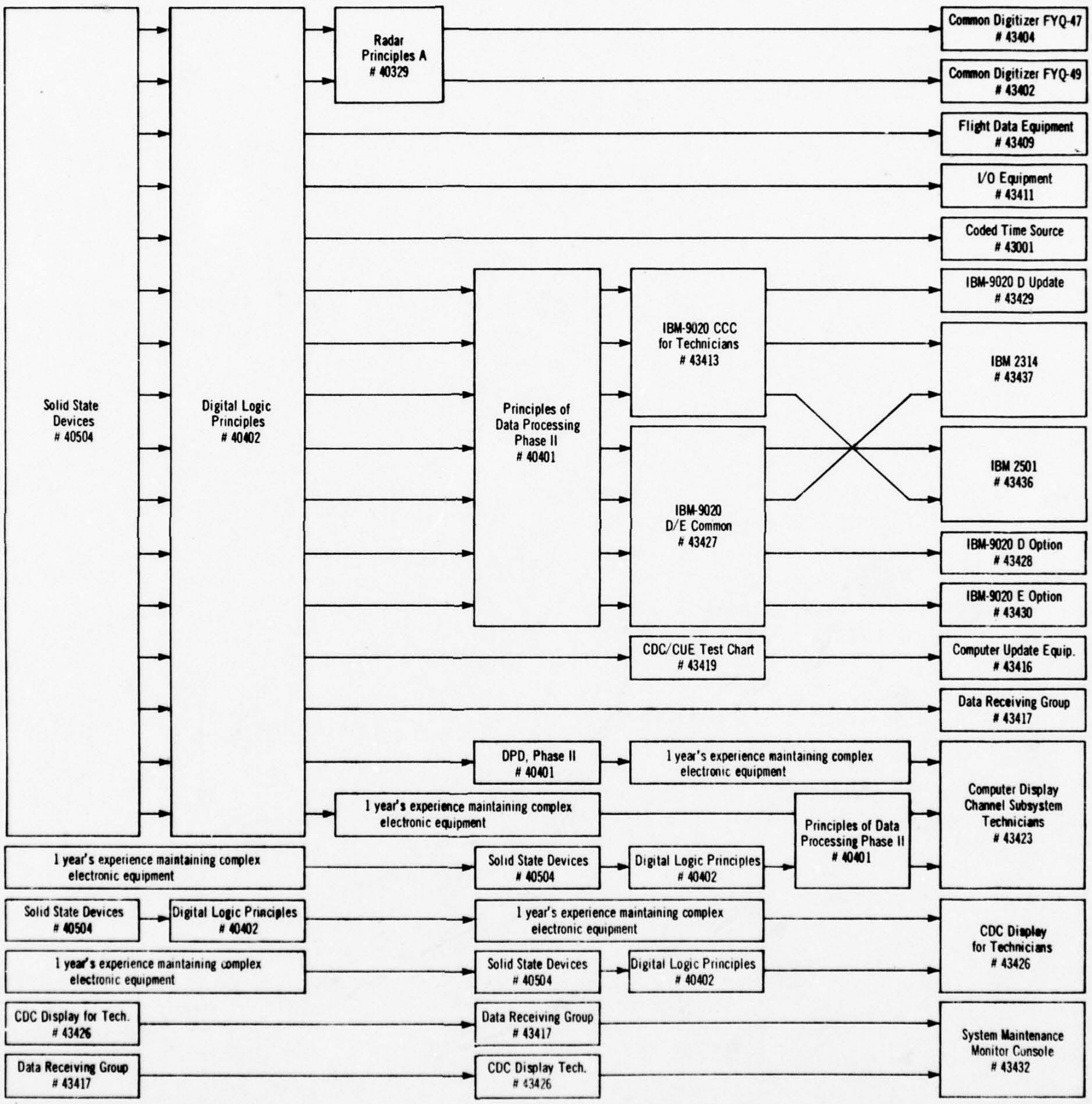


Figure 4

Electromechanical Career Field

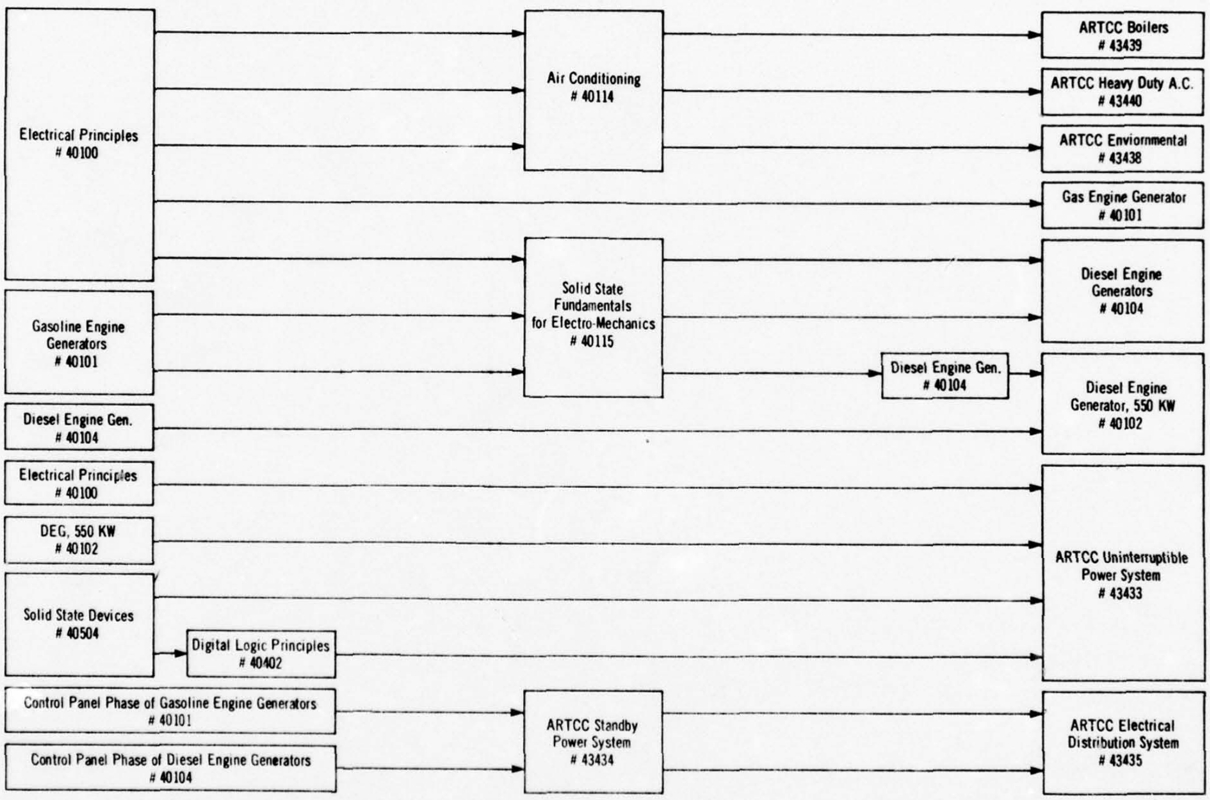


Figure 5

Radar Career Field

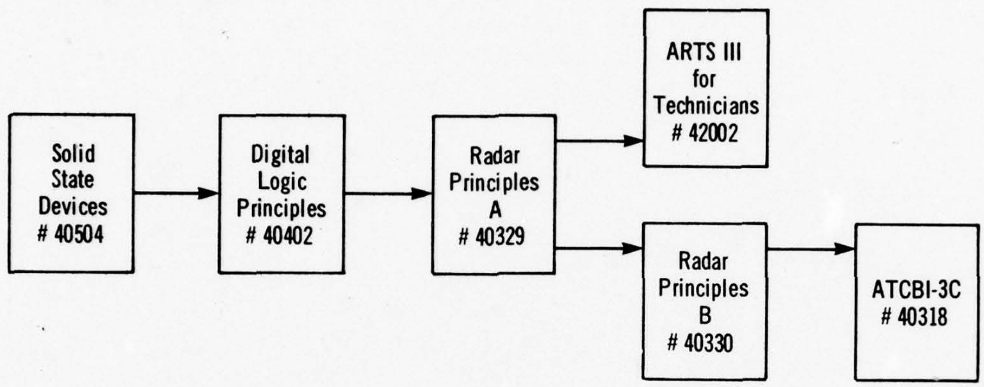
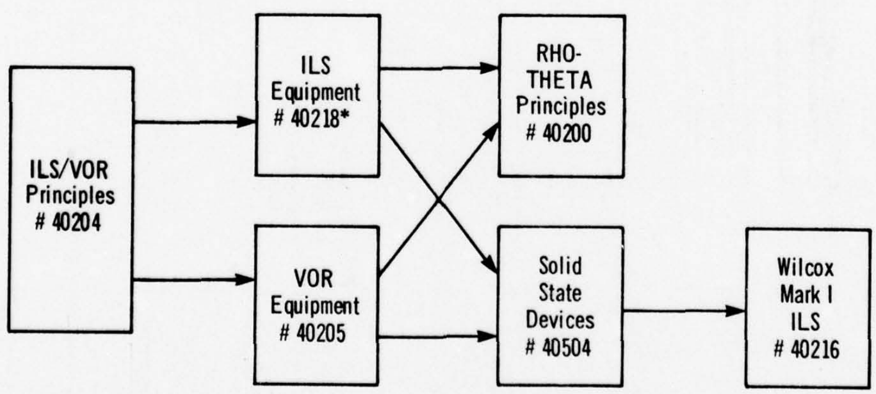


Figure 6

Navigational Aids Career Field



*No approved training plan for this course. The outline for course #40206 was used in performing the analysis.

Figure 7

Communications Career Field

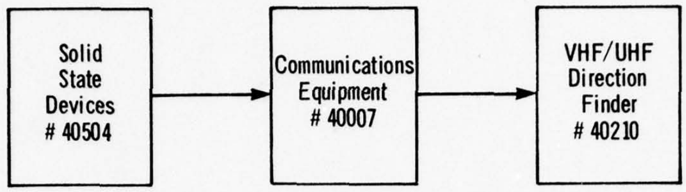


Figure 8

Electromechanical Career Field

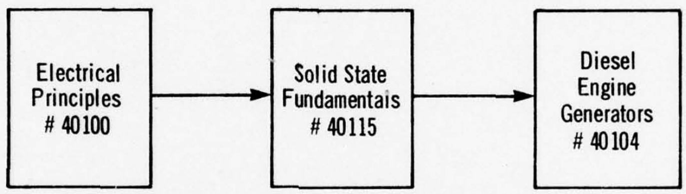


Figure 9

Data Processing Career Field

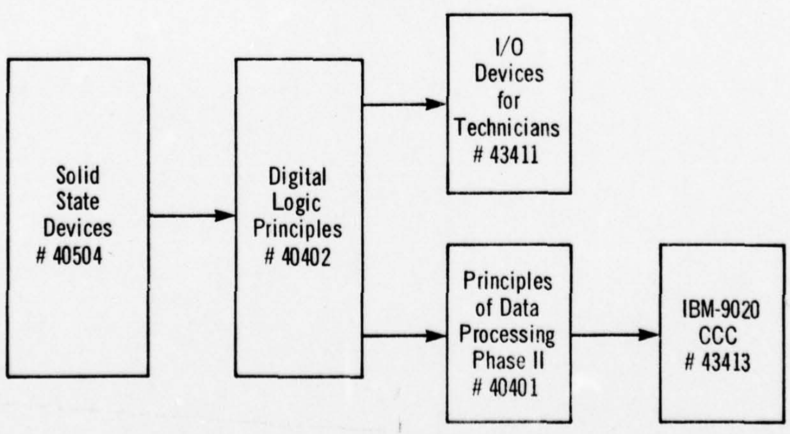


Figure 10

topics appeared in both outlines that seemed to be the same a notation was made of it, and the identification of the topic (by lesson number, or other identifier) indicated. The same process was used in comparing course 1 with course 3, and course 2 with course 3, and so forth.

For example, for the ATCBI-3 course (as shown in Figure 6) topics in Course No. 40504 Solid State Devices were compared to topics in the four other courses in the ATCBI training path. Topics in Course No. 40402, Digital Logic Principles, were compared to topics in the three other courses (the comparison with the fourth, Solid State Devices having already been made), and so forth. In all, 10 searches were made in this training path. The same process was applied to the other nine courses.

The precision with which duplicated topics were identified was a direct function of the data available for analysis. The data utilized were judged to be adequate to the purpose from a practical point of view. Instructor Guides, although containing greater depth of coverage than course outlines, still are in outline format. Instructor Lesson Plans are in a variety of formats and vary in amount of detail. Access to these two data sources would provide at best a marginal improvement in precision. Since each instructor independently prepares and presents his own lesson, there is no assurance that two instructors teaching the same topic would do so in the same way. The most precise method of determining topic duplication, using the results obtained herein as a base, would be to monitor the presentations and record them for analysis. This approach is obviously not feasible, due to scheduling and time required for data collection and analysis. The method used was the most practical one, and it was concluded that the information obtained can be used for making judgments about the reasonableness of removing certain topics.

Additional discussion concerning these matters follows the presentation of the results in Table 5. Figures 6-10 show the training paths and courses in each career field that were examined for topic duplication.

Table 5

AREAS OF TOPIC DUPLICATION

I. Within Radar Career Field

A. Between courses in ATCBI-3 path

1. Solid State Devices, Course No. 40504 and Digital Logic Principles, Course No. 40402.

Course No. 40504	**Course No. 40402**
a. Transistor switching circuits including pulse applications. (8th day)	a. Flip-flops and latches.
b. Turn on and off circuits. (9th day)	b. Basic gates

2. Solid State Devices, Course No. 40504 and Radar Principles A, Course No. 40329.

Course No. 40504	**Course No. 40329**
a. Basic Transistor Amplifier configurations (3rd day)	a. Common Emitter Transistor Amplifier
a. Common Emitter Amplifier biasing (4th day)	
a. Effect of ICO in a Common Emitter Amplifier (5th day)	
a. Transistor Audio Amplifiers (6th day)	

(Continued)

AREAS OF TOPIC DUPLICATION *(Continued)*

Course No. 40504	Course No. 40329
a. RF and IF Amplifiers (7th day)	
b. Transistor Multivibrators (8th day)	b. Transistor Type Bi-stable, monostable and emitter coupled multivibrators
c. Typical Power Supplies (10th day)	c. Power Supply Regulators

3. Solid State Devices, Course No. 40504 and Radar Principles B, Course No. 40330.

Course No. 40504	Course No. 40330
a. RF Oscillator Circuits and Crystal Oscillators (7th day)	a. Oscillator Introduction (lesson 29) a. Solid State Oscillators (lesson 31)
b. Transistor Amplifier Analogy, basic transistor configurations, basic Amplifier characteristics and Transistor Amplifiers and characteristics (all of 3rd day)	b. Parametric Amplifier (lesson 43) b. IF Amplifiers (lesson 45)
b. Class "A" operation, common base amplifier biasing, common emitter amplifier biasing, common collector amplifier biasing and transistor biasing circuits (all of 4th day)	b. Logarithmic Amplifiers (lesson 46)
b. Bias stabilization effects on amplifiers and bias stabilization circuits (all of 5th day)	
b. RF and IF Amplifiers (7th day)	

4. Solid State Devices, Course No. 40504 and ATCBI-3, Course No. 40318

Course No. 40504	Course No. 40318
a. Transistor Amplifiers, amplifier configurations, amplifier biasing and Transistor Amplifier Applications (3rd, 4th, 5th, 6th and 7th days)	a. Detailed analysis of Transistor Amplifier and multivibrator circuits found on the comparitor, sweep and amplifier driver cards (lessons 15-18)
a. Transistor switching and multivibrator circuits (8th day)	
b. The basic transistor switch (8th day)	b. Transistors and gates (lesson 10)
b. Turn on and turn off circuits (9th day)	

5. Digital Logic Principles, Course No. 40402 and Radar Principles A, Course No. 40329

Course No. 40402	Course No. 40329
a. Basic Gates	a. And, or, Nand, nor gates (lesson 50)
b. Flip-flops	b. Bi-stable M.V. (Lesson 37)
c. Counters and Registers	c. Circuit Applications - Registers, Counters (Lesson 50)

6. Digital Logic Principles, Course No. 40402 and Radar Principles B, Course No. 40330

No duplication identified.

(Continued)

AREAS OF TOPIC DUPLICATION *(Continued)*

7. Digital Logic Principles, Course No. 40402 and ATCBI-3, Course No. 40318

Course No. 40402	Course No. 40318
a. Switching logic	a. Transistors and logic (lesson 10)
b. Basic Gates	b. Transistors and Gates (lesson 11)
	b. Discussion of circuit details of Read-Write "AND" gates (lesson 17)
c. Flip-flops and Counters	c. Detailed explanation of tracking counters (lesson 40)
	c. Discussion of circuit details of program flip-flop and range flip-flop (lesson 17)
d. Logic Circuit Analysis	d. Defruiter logic diagrams

8. Radar Principles A, Course No. 40329 and Radar Principles B, Course No. 40330

Course No. 40329	Course No. 40330
a. Duplexer (lesson 6)	a. Duplexes (lesson 15)

9. Radar Principles A, Course No. 40329 and ATCBI-3, Course No. 4[illegible]

Course No. 40329	Course No. 40[illegible]
a. Beacon Transponder (lesson 9)	a. General Theory (lesson 1)
b. Beacon codes and decoding (lesson 10)	b. General Theory (lessons 2 and 3)
c. Storage tubes (lesson 54)	c. General operation and function of storage tube defruiter (lesson 13)
d. Detailed analysis of function and operation of various types of multivibrator, blocking oscillator and amplifier circuits.	d. Detailed analysis of ATCBI-3 circuitry.

The following is offered as a limited sample to illustrate the point:

(1) Blocking Oscillator (lesson 48)	(1) Free running Blocking Oscillator
(2) Cathode coupled Multivibrator (lesson 40)	(2) Cathode coupled monostable multivibrator
(3) Blocking Oscillator (lesson 48)	(3) Plate triggered Blocking Oscillator
(4) Monostable Multivibrator, plate coupled (lesson 38)	(4) Plate coupled Monostable Multivibrator
(5) Registers and Counters (lesson 50)	(5) Trinary Counter (All the above in Pulse Mode Generator, lessons 4 and 5)
(6) Differential Amplifier (lesson 25)	(6) Differential Amplifier
(7) Video Amplifiers (lesson 52)	(7) Cascade Video Amplifier (All the above in Transmitter/Receiver (lesson 8)
(8) Schmitt Circuit (lesson 43)	(8) Schmitt-Trigger Circuit
(9) Differential Amplifier (lesson 25)	(9) Difference Amplifier (Above in Monitor Circuits, lesson 10)

(Continued)

(10) Free Running Multivibrator (lesson 44)	(10) Astable Multivibrator
(11) Bi-stable Multivibrator (lesson 37)	(11) Bi-stable Multivibrator
(12) Registers and Counters (lesson 50)	(12) Binary Counters (Above in Delay Line Defruiter Circuits, lesson 40)

10. Radar Principles B, Course No. 40330 and ATCBI-3, Course No. 40318

Course No. 40330	**Course No. 40318**
a. Sensitivity Time Control (lesson 47)	a. Sensitivity Time Control—purpose and functions in system (lessons 3, 8, and 9)
b. Basic Oscillator Thoery (lesson 12)	b. Detailed analysis of tuned grid-cathode feedback, Hartley type Oscillator (lesson 5)
b. Triode Oscillator Circuits (lesson 30)	b. Analysis of Circuit Operation of crystal controlled overtone Oscillator (lesson 7)
	b. Detailed analysis of crystal controlled electron coupled Oscillator (lesson 8)
c. IF Amplifiers (lesson 45)	c. Detailed analysis of IF Amplifier (lesson 8)

11. ATCBI-3, Course No. 40318 and ARTS III for Technicians, Course No. 42002

Due to the nonavailability of more detailed lesson plans, for the ARTS III Course, it is not possible to make any meaningful judgments on topic duplication.

B. Between courses in the ARTS III path

The explanatory note at No. 11 also applies here. However, it should be observed that there are three courses which are common to both the ATCBI-3 path and the ARTS III path. Topic duplication between these three courses is discussed under the ATCBI-3 path and will not be repeated here.

II. Within Navigational Aids Career Field

A. Between courses in the Rho-Theta Principles Path

1. ILS/VOR Principles, Course No. 40204 and VOR Equipment, Course No. 40205

Course No. 40204	**Course No. 40205**
a. Circuit Analysis Phase Comparator and Ambiguity Circuits (lecture no. 4, 3rd day)	a. FA-5226 Phase Comparator and Ambiguity Circuits (3rd period, 7th day)

2. ILS/VOR Principles, Course No. 40204 and ILS Equipment, Course No. 40218

Course No. 40204	**Course No. 40218**
a. Radiation Patterns, Specific Antenna Pairs (lecture no. 5, 13th day and lecture no. 6, 14th day)	a. ILS Specific Antenna Pairs and Radiation Patterns (1st period, 3rd day)
a. Radiation Patterns Alfred Loop (lecture no. 7, 15th day)	

(Continued)

AREAS OF TOPIC DUPLICATION *(Continued)*

Course No. 40204	**Course No. 40218**
b. Radiation Patterns (lecture no. 1 and Problem Session, 9th day; lecture no. 2 and Problem Session, 10th day; lecture no. 3 and laboratory, 11th day; lecture no. 4 and Problem Session, 12th day; lecture no. 5 and laboratory, 13th day; lecture no. 6, 14th day and lecture no. 7, 15th day)	b. Radiation Patterns (1st, 2nd, 3rd and 4th periods, 3rd day; 1st, 2nd, 3rd and 4th periods, 4th day and 1st and 2nd periods, 5th day)

3. ILS/VOR Principles, Course No. 40204 and Rho-Theta Principles, Course No. 40200

Course No. 40204	**Course No. 40200**
a. Circuit Analysis Phase Inverters and Phase Shift Networks (lecture no. 3, 2nd day)	a. RC Phase Shifters (lesson 8, FD-202) a. Phase Inverters (lesson 22, FD-202)
b. Circuit Analysis RC Circuits (lecture no. 6, 5th day)	b. RC Circuit Transients (lesson 6, FD-202) b. RC Coupled Amplifiers (lesson 18, FD-202) b. Basic Sweep Circuits (lesson 17, FD-203)
c. Amplitude Modulation (lecture 1 and Problem Session, 2nd day; lecture no. 2, 3rd day; lecture no. 3 and Problem Session, 4th day; lecture no. 4 and lab no. 1, 5th day)	c. Amplitude Modulation (lesson 5, FD-202)
d. Equivalent Circuit Analysis Grounded Cathode and Cathode Degeneration (lesson 1, 1st day)	d. Pulse Amplifiers (lesson 19, FD-202) d. Feedback in Amplifiers (lesson 20, FD-202)

Course No. 40204	**Course No. 40200**
e. Radiation Patterns (lecture no. 1 and problem session, 9th day; lecture no. 2 and problem session, 10th day; lecture no. 3 and lab demonstration no. 1, 11th day; lecture no. 4 and problem session, 12th day; lecture no. 5 and lab demonstration no. 2, 13th day; lecture no. 6, 14th day; and lecture no. 7, 15th day)	e. Introduction to Rho-Theta Antenna (lesson 20, FD-201) e. Development of the Radiation Pattern (lesson 21, FD-201) e. Multilobed Radiation Patterns from two-dipole arrays (lesson 22, FD-201)
f. Circuit Analysis Clampers (lecture no. 7, 6th day)	f. Clampers and Detectors (lesson 14, FD-202)
g. Transmission lines (lecture no. 1, 7th day)	g. Introduction to Coaxial Transmission Lines (lesson 10, FD-201)
h. Transmission Lines (lecture no. 2, 8th day)	h. Reflection Coefficient (lesson 10, FD-201) h. Standing Waves (lesson 11, FD-201)

(Continued)

AREAS OF TOPIC DUPLICATION *(Continued)*

Course No. 40204	Course No. 40200
i. Related instruction on Transmission Lines (problem session, 7th day; lab no. 1, 8th day; lecture no. 3 and lab no. 2, 9th day; lecture no. 4 and lab no. 3, 10th day; lecture no. 6 and problem session, 12th day; lecture no. 7 and problem session, 13th day; lab no. 4 and lecture no. 8, 14th day; and lecture no. 9, 15th day)	i. Transmission Line Attenuation and Quarter-Wavelength Sections (lesson 12, FD 201)

4. ILS Equipment, Course No. 40218 and Rho-Theta Principles, Course No. 40200
   a. Unable to identify any areas of topic duplication between the above courses.

5. VOR Equipment, Course No. 40205 and Rho-Theta Principles, Course No. 40200
   a. Unable to identify any topic duplication between the above courses.

B. Between courses in the WILCOX MARK I ILS Path

1. ILS/VOR Principles, Course No. 40204 and VOR Equipment, Course No. 40205
   a. See comments at II-A-1.

2. ILS/VOR Principles, Course No. 40204 and ILS Equipment, Course No. 40218
   a. See comments at II-A-2.

3. ILS/VOR Principles, Course No. 40204 and Solid State Devices, Course No. 40504

Course No. 40204	Course No. 40504
a. FM Detection (lecture 8)	a. AM and FM Detector Circuits (7th day)
b. AGC Circuits (lecture 8)	b. AGC Circuits (7th day)

4. ILS/VOR Principles, Course No. 40204 and WILCOX MARK I ILS, Course No. 40216

Note: Detailed lesson plans or guides were not available for the MARK I ILS Course, and consequently the efforts to identify duplicate topics between the MARK I ILS Course and other courses suffer in specificity and completeness. The training manual for the MARK I Course was used as a data source due to the absence of other information concerning course topics.

Course No. 40204	Course No. 40216
a. Amplitude Modulation (lecture no. 1 and problem session, 2nd day; lecture no. 2, 3rd day; lecture no. 3 and problem session, 4th day; lecture no. 4 and lab no. 1, 5th day; and review, 6th day)	a. Amplitude Modulation (3rd period, 5th day)
b. Radiation patterns specific Antenna Pairs (lecture no. 5, 13th day and lecture no. 6, 14th day)	b. Specific Pair Radiation (1st and 2nd periods, 7th day)

(Continued)

AREAS OF TOPIC DUPLICATION *(Continued)*

Course No. 40204

c. Radiation Patterns (lecture no. 1 and problem session, 9th day; lecture no. 2 and problem session, 10th day; lecture no. 3 and lab no. 1, 11th day; lecture no. 4 and problem session, 12th day; lecture no. 5 and lab no. 2, 13th day; lecture no. 6, 14th day; and lecture no. 7, 15th day)

d. Reflection coefficient (lecture no. 2, 8th day)

Course No. 40216

c. Radiation Patterns (3rd and 4th periods, 7th day; 1st, 2nd, 3rd and 4th periods, 8th day; 1st and 2nd periods, 9th day; 3rd period, 16th day; and 3rd period, 19th day)

d. Ground Effects (3rd period, 19th day)

d. Reflection coefficient measurements (4th period, 19th day)

5. VOR Equipment, Course No. 40205 and Solid State Devices, Course No. 40504

   a. Unable to identify any areas of topic duplication between these two courses. Being somewhat speculative, and based upon the types of topic found duplicated in other courses, one would suspect that if there is an area where topic duplication is likely to occur it would be in detailed analysis of circuits. For the purposes here, it would most likely be found between detailed analyses of Solid State Circuits (if any exist) found in the VOR equipment and similar type analyses of basic circuits and specific applications of these in various types of equipment (6th and 7th days) in the Solid State Devices Course.

6. VOR Equipment, Course No. 40205 and WILCOX MARK I ILS, Course No. 40216.

Course No. 40205

a. Oscillator-Keyer (3rd and 4th periods, 4th day)

b. Goniometer (1st period, 3rd day)

Course No. 40216

a. Oscillator-Keyer (3rd period, 13th day and 1st, 2nd, 3rd and 4th periods, 14th day)

b. Mechanical Modulation (1st period, 12th day)

7. ILS Equipment, Course No. 40218 and Solid State Devices, Course No. 40504

   a. Unable to identify any areas of topic duplication between the above courses.

8. ILS Equipment, Course No. 40218 and WILCOX MARK I ILS, Course No. 40216

Course No. 40218

a. The ILS (3rd period, 1st day)

b. ILS AM and DDM (1st period, 2nd day)

c. ILS Wave Forms (2nd and 4th periods, 2nd day)

d. DDM and ILS Receivers (3rd period, 2nd day)

e. ILS and Specific Antenna Pairs and Radiation Patterns (1st period, 3rd day)

Course No. 40216

a. The ILS System (2nd period, 1st day)

b. AM and DDM (3rd period, 5th day)

c. ILS Wave Forms (4th period, 5th day and 2nd period, 6th day)

d. DDM and ILS Receivers (1st period, 6th day)

e. Specific Pair Radiation (1st and 2nd periods, 7th day)

(Continued)

AREAS OF TOPIC DUPLICATION *(Continued)*

Course No. 40218	Course No. 40216
f. Radiation Pattern Measurements (2nd period, 3rd day)	f. Radiation Pattern Measurements (3rd and 4th periods, 7th day; 2nd and 4th periods, 8th day; and 2nd period, 9th day)
g. Glide Slope Radiation Pattern and DDM (1st and 2nd periods, 5th day)	g. Wilcox Glide Slope DDM and Radiation Patterns (1st and 2nd periods, 9th day)
h. Mechanical Modulator (3rd and 4th periods, 9th day and 3rd and 4th periods, 10th day)	h. Mechanical Modulation Block Diagram (1st period, 12th day) h. Mechanical Modulator (3rd period, 12th day and 1st period, 13th day)
i. Sideband ACU (3rd period, 13th day) i. Localizer Phasing (1st and 2nd periods, 14th day and 3rd and 4th periods, 15th day) i. Glide Slope Phasing (3rd and 4th periods, 14th day)	i. RF Phasing and ACU (3rd period, 15th day)
j. ILS Proximity Error (3rd period, 16th day)	j. Proximity Phase Lag General (3rd period, 17th day)
k. Glide Slope Proximity Phase Lag (3rd period, 17th day)	k. Glide Slope Proximity Phase Lag and Offset (3rd and 4th periods, 18th day)
l. Localizer Proximity Phase Lag (1st period, 17th day)	l. Localizer Proximity Phase Lag (1st period, 18th day)
m. V-Ring RF Distribution (3rd and 4th periods, 26th day)	m. V-Ring Distribution Unit (1st and 2nd periods, 16th day)
n. V-Ring Monitoring (3rd period, 27th day)	n. V-Ring Monitoring System (1st period, 17th day)
o. V-Ring Radiation Patterns (1st and 2nd periods, 27th day)	o. V-Ring Radiation Patterns (3rd period, 16th day)
p. Ground Inspection (1st, 2nd, 3rd and 4th periods, 19th day)	p. Ground Inspections (1st, 2nd and 4th periods, 28th day)
q. Flight Inspections (1st, 2nd, 3rd and 4th periods, 20th day)	q. Flight Inspections (3rd period, 28th day and 2nd period, 29th day)

Note: A broad and general area for possible duplication of information could be in the discussion and description of the functions and/or purposes of the various equipments comprising the ILS System; e.g., the monitors, field detectors, modulators. This would also be true at the circuit level—such as, the Oscillator-Keyer, AGC Circuits, Modulator, Alarm Circuits, etc.

9. Solid State Devices, Course No. 40504 and WILCOX MARK I ILS, Course No. 40216

Course No. 40504	Course No. 40216
a. Transistor Circuit Servicing and Testing (10th day)	a. Solid State Device Testing (4th period, 2nd day) a. Circuit Board Component Replacement (4th period, 3rd day)

(Continued)

AREAS OF TOPIC DUPLICATION *(Continued)*

Course No. 40504	Course No. 40216
b. RF Oscillator and Crystal Oscillator Circuits (7th day)	b. Analysis of RF Oscillator Circuits (Transmitter, 3rd period, 11th day; Monitor Detector, 3rd period, 20th day, and 1st and 2nd periods, 21st day; Monitors, 3rd and 4th periods, 21st day and 1st and 2nd periods, 22nd day)
c. Transistor Switches and Multivibrators (8th day)	c. Analysis of Multivibrator and Transistor Switches Circuits (1st and 3rd periods, 14th day; 3rd period, 20th day; 1st and 2nd periods, 21st day)
d. Special Devices (SCR and FET) (9th day)	d. Analysis of circuits incorporating FETs and SCRs (3rd period, 11th day; 1st and 2nd periods, 12th day; 1st and 2nd periods, 21st day)
	d. Solid State Devices and Circuits (3rd period, 2nd day; 3rd period, 3rd day)
e. Integrated Circuits (10th day)	e. Integrated Circuits (3rd period, 4th day)
f. Modulators and Detector Circuits (7th day)	f. Analysis of Modulator Circuits and Detectors (3rd period, 12th day and 1st period, 13th day)
g. Power Supplies (10th day)	g. Analysis of Power Supply Circuits (Transmitter, 1st period, 11th day; Modulator, 1st and 2nd periods, 12th day; Monitors, 3rd period, 21st day)
h. Transistor Audio Amplifiers (6th day)	h. Audio Amplifier Circuit Analysis (1st period, 27th day)
i. RF Amplifier and RF Power Amplifier Circuits (7th day)	i. Analysis of RF Amplifier and RF Power Amplifier Circuits (3rd period, 11th day)
j. Frequency Multipliers (7th day)	j. Analysis of Doubler Circuit (3rd period, 11th day)

C. Between Rho-Theta Principles, Course No. 40200 and WILCOX MARK I ILS, Course No. 40216

NOTE: The major area of topic duplication between these two courses would most likely occur during the detailed analysis of circuits in MARK I ILS equipment. The following *is a selected sample of these areas:*

Course No. 40200	Course No. 40216
a. RL Transients-Integrators-Differentiators (lesson no. 7, FD-202)	a. Differentiating Circuits
b. Regulating Circuits (lesson 23, FD-202)	b. Power Supplies Circuitry

(Continued)

AREAS OF TOPIC DUPLICATION *(Continued)*

Course No. 40200

c. Gating Circuits (lesson 24, FD-202)
d. Multivibrators (lessons no. 7, 8, 9, 10, 11 and 12, FD-203)
e. Gated Oscillators (lesson no. 15, FD-203)
f. Counters (lesson 22 and 23, FD-203)

Course No. 40216

c. AND and OR Circuits
d. Timing and Control Circuits incorporating various types of Multivibrators and Relaxation Oscillators
e. Gated Oscillators
f. Binary Counters

III. Within Communications Career Field

A. Between courses in the VHF/UHF Direction Finder Path

1. Solid State Devices, Course No. 40504 and Communications Equipment, Course No. 40007

Course No. 40504

a. Transistor audio amplifiers (6th day) Field effect Transistor (9th day) Typical power supplies (10th day)
b. RF Circuits (7th day)
c. Transistor Audio Amplifiers (6th day) and typical power supplies (10th day) and RF Circuits (7th day)
   (1) RF and IF Amplifiers
   (2) Mixer Circuits
   (3) Detector Circuits
   (4) AGC Circuits
   (5) Crystal Oscillators
   (6) Buffer Amplifiers and Frequency Multipliers
   (7) RF Power Amplifiers

Course No. 40007

a. Circuit analysis of Solid State Regulated Output Amplifiers and Solid State Amplifiers (lesson 2-2)
b. Circuit Analysis (TV-36) Solid State Crystal Oscillator, Buffer Amplifiers, Frequency Multipliers, RF Amplifiers, and AGC Circuits (lessons 19-2, 20-2A and 20-2B)
c. Circuit Analysis of Solid State Receiver (ANGRR-24) circuits
   (1) Crystal Oscillator
   (2) Buffer Amplifier
   (3) Mixer/Multiplier
   (4) IF Amplifier
   (5) AGC Circuit
   (6) Audio Amplifier
   (7) Power Supply
   (8) RF Amplifiers (lessons 35-2, 36-1, and 36-2)
c. Detailed Circuit Analysis of Solid State Transceiver (TRU-2) Circuits
   (1) RF Amplifiers
   (2) Frequency Multipliers
   (3) Mixers
   (4) IF Amplifiers
   (5) Audio Amplifiers
   (6) Crystal Oscillator
   (7) AGC Circuit
   (8) RF Power Amplifiers

(Continued)

AREAS OF TOPIC DUPLICATION *(Continued)*

2. Solid State Devices, Course No. 40504 and VHF/UHF Direction Finder, Course No. 40210

Course No. 40504

a. Transistor Switching Circuits
   (1) The Basic Transistor Switch
   (2) Transistor Multivibrators (8th day)

b. Typical Power Supplies (10th day)

c. Transistor Multivibrators (8th day)

Course No. 40210

a. Antenna System Switching utilizing Diodes and Transistors (periods 2-2 and 3-2)

a. Detailed Analysis of Antenna Switching System

b. Power Supplies (Receiver) (periods 4-2 and 5-1)

c. Detailed Analysis of Noise Gating Circuits (periods 6-1 and 6-2)

c. Circuit Analysis of Frequency Dividers and Reference Generator (periods 8-1 and 8-2A)

3. Communication Equipment, Course No. 40007 and VHF/UHF Direction Finder, Course No. 40210

Course No. 40007

a. Circuit Analysis
   (1) Crystal Oscillator (TMS, lessons 15-1A and 15-1B)

a. Circuits Analysis
   (1) Oscillator-doubler
   (2) Frequency Multipliers (TV-3, lessons 16-1A, 16-1B and 16-2A)

a. General Concepts
   (1) Class "C" RF Amplifiers (lesson 17-1)

a. Circuit Analysis
   (1) Butler Oscillator
   (2) Double Circuit (TV-6, lessons 17-2A and 17-2B)

a. Circuit Analysis
   (1) Crystal Oscillator
   (2) Multiplier Circuits (TUQ, lessons 18-2A and 18-2B)

a. Circuit Analysis
   (1) AGC Systems
   (2) RF Amplifiers
   (3) Oscillator-Multiplier chain
   (4) IF Amplifier
   (5) Mixers
   (6) Audio System (RV-6 and RV-9, lessons 31-1 and 31-2)

a. Theory and Circuit Analysis of
   (1) Butterworth Filters (lessons 33-1, 33-2 and 34-1)

Course No. 40210

a. Analysis of Receiver Circuits
   (1) RF Amplifiers
   (2) Crystal Oscillators
   (3) Mixers
   (4) Frequency Tripler
   (5) IF Amplifiers
   (6) Audio Circuits
   (7) AGC
   (8) Butterworth Filter (lessons 4-2 and 5-1)

(Continued)

AREAS OF TOPIC DUPLICATION *(Continued)*

IV. Within the Electro-Mechanical Career Field

A. Between courses in the Diesel Engine Generator path

1. Electrical Principles, Course No. 40100 and Solid State Fundamentals, Course No. 40115

Course No. 40100	**Course No. 40115**
a. Conductors and insulators (lecture 2-3)	a. Classification of elements by conduction (lecture 1)
b. Laboratory familiarization with meters (lab 2-2)	b. Laboratory equipment familiarization (lab 1)
c. Instantaneous, max, RMS and average voltage and current (lecture 11-3)	c. Peak, RMS and average values of sinusoidal wave forms (lecture 2)
d. Half-wave rectifier circuits (lecture 18-3)	d. The junction diode half-wave rectifier (lecture 3)
e. Full-wave rectifier circuits (lecture 18-4)	e. The junction diode full-wave rectifier and the full-wave bridge rectifier (lecture 3)
	e. Rectifier filters (lecture 3)

2. Electrical Principles, Course No. 40100 and Diesel Engine Generators, Course No. 40104

Course No. 40100	**Course No. 40104**
a. Relays and relay control. Construction and operation of relays (lecture 19-4 and lab 21-2)	a. Relays and relay circuits (lab, 3rd period, 2nd day)
b. Circuit diagrams used in course	b. Circuit symbols (1st period, 2nd day)

3. Solid State Fundamentals, Course No. 40115 and Diesel Engine Generators, Course No. 40104

Course No. 40115	**Course No. 40104**
a. Circuit diagrams used in course	a. Circuit symbols (1st period, 2nd day)
b. Differential amplifiers (lecture 10)	b. Theory of operation of Inet Sprague Solid State Voltage Regulator Circuits
b. Full-wave Bridge Rectifier (lecture 3)	(1) Differential amplifier (2) Full-wave Bridge Rectifier (1st and 2nd periods, 7th day)
c. Silicon Controlled Rectifier (SCR) (lecture 8)	c. Description of SCR action in G.E. SCR Voltage Regulator (1st period, 8th day)

V. Within the Data Processing Career Field

A. Between Courses in the NAS En Route Automation I/O Equipment for Technicians path

1. Solid State Devices, Course No. 40504 and Digital Logic Principles, Course No. 40402

   a. See I-A-1 for content duplication between these courses.

2. Solid State Devices, Course No. 40504 and NAS I/O Equipment for Technicians, Course No. 43411

   a. Unable to identify any content duplication between the above courses.

AREAS OF TOPIC DUPLICATION *(Continued)*

3. Digital Logic Principles, Course No. 40402 and NAS I/O Equipment for Technicians, Course No. 43411

    a. Unable to identify any content duplication between the above courses.

B. Between courses in IBM-9020 CCC path

1. Solid State Devices, Course No. 40504 and Digital Logic Principles, Course No. 40402

    a. See I A-1 for topic duplication between these courses.

2. Solid State Devices, Course No. 40402 and Principles of Data Processing, Phase II, Course No. 40401

Course No. 40402	**Course No. 40401**
a. Typical Power Supplies (10th day)	a. Power Supplies (12th day)

3. Solid State Devices, Course No. 40504 and IBM-9020 CCC, Course No. 43413

    a. Unable to identify any topic duplication between the above courses.

4. Digital Logic Principles, Course No. 40402 and Principles of Data Processing, Phase II, Course No. 40401

    a. Unable to identify any topic duplication between the above courses.

5. Digital Logic Principles, Course No. 40402 and IBM-9020 CCC, Course No. 43413

    a. Unable to identify any topic duplication between the above courses.

6. Principles of Data Processing, Phase II, Course No. 40401 and IBM-9020 CCC, Course No. 43413

Course No. 40401	**Course No. 43413**
a. Input/output typewriter operation (20th day)	a. 1052 Typewriter operation (14th day)
b. Programming "debugging" (2nd day)	b. Program Debugging system (18th day)

C. Between NAS En Route Automation I/O Equipment for Technicians, Course No. 43411 and IBM-9020 CCC, Course No. 43413

Course No. 43411	**Course No. 43413**
a. 1052 Printer Keyboard (lessons 1 and 2, lab no. 1)	a. 1052 Typewriter Operation (14th day)

b. Comment: Both of the above courses devote considerable time to tracing signals or events through the Automated Logic Diagrams. If the primary purpose of this instruction is to enable the student to (a) identify and locate the appropriate ALD and (b) extract all required information for the task at hand, then time would be spent in both courses developing the same basic skills and knowledges. If the purpose is to provide the student with information on the logic (how and why) of certain operations or events, then there would not be any duplication.

(Continued)

TOPIC DUPLICATION ACROSS CAREER FIELDS (RADAR—NAVAIDS)

Radar Principles A	Rho-Theta Principles
1) Network Theorems (lesson 19)	1) Network Laws and Theorems (lesson 5, FD-202)
2) Vacuum Tube Parameters (lesson 20)	2) Vacuum Tube and Semiconductor Diodes (lesson 17, FD-202), Diode Applications and Introduction to Triode Characteristics (lesson 18, FD-202), Triode Vacuum Tube Analysis (lesson 19, FD-202), and Multi-element Tube Characteristics and Applications (lesson 20, FD-202)
3) Equivalent Circuit Analysis, Miller Effect and Grounded Grid Amplifiers (lesson 21)	3) Vacuum Tube Parameters (lesson 20, FD-202) and the Ground Grid and Cascade Amplifier (lesson 24, FD-202)
4) Cathode Follower (lesson 23)	4) Feedback in Amplifiers (lesson 23, FD-202)
5) Differential Amplifier (lesson 25)	5) Phase Inverters and Overdriven Amplifiers (lesson 25, FD-202)
6) Feedback Amplifiers (lesson 26)	6) Feedback in Amplifiers (lesson 23, FD-202)
7) Power Supply Regulators (lesson 28)	7) Regulating Circuits (lesson 27, FD-202)
8) Complex Waveform Analysis (lesson 29)	8) Non-sinusoidal Waveform Synthesis and Analysis (lesson 3, FD-202)
9) R.C. Transient Analysis (lesson 30)	9) R.C. Circuit Transients (lesson 6, FD-202)
10) R.C. Circuits (lesson 31)	10) Time Constant Variations in R.C. Circuits (lesson 8, FD-202) and Applications of RC and RL Circuits (lesson 11, FD-202)
11) Diode Clamping and Diode Clipping (lesson 32)	11) Vacuum Tube and Semiconductor Diodes (lesson 17, FD-202) and Diode Applications and Introduction to Triode Characteristics (lesson 18, FD-202)
12) Sweep Circuits (lesson 33)	12) Characteristics of Simple R.C. Sweep Circuits (lesson 22, FD-203) and Practical Sweep Circuits (lesson 23, FD-203)
13) R.L. Transients (lesson 34)	13) R.L. Transients – Integrators – Differentiators (lesson 7, FD-202)
14) RLC Fundamentals (lesson 35)	14) Characteristics of Resonant Circuits (lesson 10, FD-202)
15) RLC Ringing and Peaking Circuits (lesson 36)	15) Ringing Circuits and Gated Oscillators (lesson 20, FD-203) and Pulsed Oscillators and Peaking Circuits (lesson 21, FD-203)

(Continued)

TOPIC DUPLICATION ACROSS CAREER FIELDS (RADAR–NAVAIDS)

(Continued)

Radar Principles A	Rho-Theta Principles
16) Bi-stable M.V. (lesson 37)	16) The Bi-stable Multivibrator with External Bias (lesson 14, FD-203) and Self-biased Bi-stable Multivibrators (lesson 15, FD-203)
17) Monostable M.V. (lesson 38)	17) Plate Coupled Monostable Multivibrators (lesson 10, FD-203)
18) Cathode Coupled M.V. (lessons 40 and 41)	18) Cathode Coupled Monostable Multivibrators (lesson 11, FD-203) and the Cathode Coupled Bi-stable Multivibrator (lesson 16, FD-203)
19) Quantizers (lesson 43)	19) The Cathode Coupled Bi-stable Multivibrator (lesson 16, FD-203), Schmitt Circuit Biasing and Hysteresis (lesson 17, FD-203) and applications of Bi-stable Multivibrators and Schmitt Circuits (lesson 18, FD-203)
20) Freerunning M.V. (lesson 44)	20) Astable Multivibrators (lesson 12, FD-203)
21) Phantastron-Screen Coupled (lesson 45)	21) Screen Coupled Phantastron (lesson 24, FD-203)
22) Phantastron-Cathode Coupled (lesson 46)	22) Cathode Coupled Phantastron Frequency Divider (lesson 25, FD-203)
23) Pulse Transformer (lesson 47)	23) Pulse Transformers and the Monostable Blocking Oscillator (lesson 26, FD-203)
24) Blocking Oscillator (lesson 48)	24) Pulse Transformers and the Monostable Blocking Oscillator (lesson 26, FD-203) and the Blocking Oscillator (lesson 27, FD-203)
25) Circuit Applications (lesson 50)	25) Gating Circuits (lesson 28, FD-202)
26) Video Amplifiers (lesson 52)	26) Basic Amplifier Frequency Response (lesson 21, FD-202) and Amplifier Response to the Application of a Pulse (lesson 22, FD-202)

Radar Principles B	Rho-Theta Principles
1) Introduction to Transmission Lines (lesson 1)	1) Introduction to Transmission Lines (lesson 9, FD-201)
2) Transmission Lines (lessons 2 and 3)	2) Introduction to Transmission Lines (lesson 9, FD-201) and Standing Waves and Impedance Variations on Transmission Lines (lesson 10, FD-201)
3) Standing Wave Ratio (lesson 4) and Transmission Line Analysis (lesson 5)	3) Standing Waves and Impedance Variations on Transmission Lines (lesson 10, FD-201) and Transmission Line Attenuation and Quarter Wave-length Transformers (lesson 11, FD-201)
4) Striplines and TEM Waves (lesson 6)	4) Cylindrical Cavity Resonators (lesson 14, FD-201)

(Continued)

TOPIC DUPLICATION ACROSS CAREER FIELDS (RADAR—NAVAIDS)

(Continued)

Radar Principles B	Rho-Theta Principles
5) Electromagnetic Waves (lesson 7)	5) Electromagnetic Waves (lesson 8, FD-201)
6) Cylindrical Guide Modes and Automation (lesson 10)	6) Cylindrical Cavity Resonators (lesson 14, FD-201)
7) Power Klystron (lesson 35)	7) Introduction to Power Klystrons (lesson 17, FD-201)
8) Radar Antennas (lessons 16 and 17) and Array Type Antennas (lesson 18)	8) Introduction to Rho-Theta Antenna Systems (lesson 21, FD-201), Radiation Patterns from Dipole Arrays (lesson 22, FD-201), Multielement Antenna Array Radiation Patterns (lesson 23, FD-201) and Rho-Theta Antenna Systems (lesson 24, FD-201)
9) Noise (lesson 41) and Noise Figure Measurement (lesson 42)	9) Introduction to Microwave Receivers (lesson 1, FD-203)
10) Mixers (lesson 44)	10) Frequency Conversion (lesson 2, FD-203)
11) IF Amplifiers (lesson 45)	11) Single Tuned IF Amplifiers (lesson 4, FD-203) and Double Tuned IF Amplifiers and Practical Considerations (lesson 5, FD-203)

DISCUSSION

Upon examination of the various resident training paths, the following observations are warranted.

(1) Course entry level, background, and experience of trainees

The prerequisites for some courses permit entry of students from two or more career fields and new hires. This means that trainees entering such courses may differ greatly in previous training and work experience. For example, trainees could include new hires with preparatory training for solid state and integrated circuits, and certified technicians on basically vacuum tube-type equipment, and certified technicians on solid state-type equipment. Consequently, a considerable effort would be required of the instructor to accommodate his instruction so that trainees with such heterogeneous backgrounds could profit from equipment specific training.

Examples of such courses are: ATCBI-4 (No. 40334) and ATCBI-3 (No. 40316) and RML-2 (No. 40320) courses in the Radar career field, the Teletype Equipment (No. 40012) course in the Communications career field, the UPS (No. 43433) course in the Electromechanical career field.

(2) The Navaids Career Field

To reiterate a previous point, the figures contain only resident training paths which represent the system today. The observations being made are underpinned by two assumptions: (a) the training paths will remain basically the same for some time, and (b) large numbers of maintenance personnel will follow these paths.

In the Navaids course (Figure 1) the location of the Solid State Devices and Digital Logic Principles courses occurs later in certain training paths than they do in either Radar or Data Processing. These courses would have to be taken by an RTN-2, or

RTC-1 technician were he to cross career fields into Data Processing. Because of the training investment already made in the RTN-2 or RTC-1 technician, it is concluded that such technicians would be poorer choices to cross over into Data Processing than, say, a technician certified for only one equipment in the Radar field.

The prerequisites of the RTN-2 or RTC-1 courses are such that Radar technicians could be admitted to them. This could occur, in particular, in the case where the technician had completed the Rho-Theta principles. In some cases, the Radar technicians could have completed: Solid State Devices, Digital Logic Principles, and either RADAR Principles A or RADAR Principles A and B before entering the Rho-Theta Principles course.

The fact that in the Navigational Aids Career Field, Solid State Devices and Digital Logic Principles courses follow the RTN-2 and RTC-1 courses implies that the content of the two former courses is not required for mastery of the content of the two latter courses. Yet some Radar technicians crossing into the Navaids career field for training in the RTN-2 or RTC-1 could have had that apparently superfluous training. That is, since Solid State Devices and Digital Logic Principles are not prerequisite to RTN-2 and RTC-1 but are for Radar technicians, they represent a training investment without any apparent immediate utility to the Radar technician moving into the Navaids career field. The total training investment to qualify a Radar technician in RTN-2 or RTC-1 would be substantially greater than that for a new hire in the Navaids career field.

Additional comments and recommendations on career progression and topic duplication are included in Volume II.

CORE CURRICULUM

The advisability of establishing a core curriculum necessarily rests on the present status of ANF courses. On the basis of the analysis performed under duplication of topics, there appear to be numerous instances where the same or similar topics are presented in a series of related courses within a given career field. In addition, within the constraints of the examination of duplicate topics across career fields, it is apparent that topic duplication is also present in this context.

The existence of duplicated topics both within career fields and across them gives rise to considering the possibility of either creating a core curriculum, appropriate to all career fields, or removing duplicated topics within career fields. It would be possible to remove duplicated topics within a career field with the effect of reducing training time. As perhaps an interim measure this may be a beneficial thing to do.

The larger question of what each course should contain depends upon accurate identification of what the job requires the man to do, and precise specification of performance standards. The redefinition of the course in terms of job requirements should take priority over restructuring done by eliminating duplicated material. Because of the foregoing, it is considered inadvisable to establish a core curriculum at the present time; however, removal of duplicated topics may be planned as an interim measure in those instances where it has been detected. (Additional comments on this matter will be found in Volume II.)

Chapter 3

EVALUATION OF THE INSTRUCTIONAL PROGRAM (TASK B)

OBJECTIVE

The objective of this task was to determine the extent to which the present instructional program meets valid training outcomes. The evaluation of the effectiveness of the instructional activities consisted of a consideration of the following factors:

(1) Use of job analyses and related techniques
(2) Analysis of training objectives
(3) Availability of training plans
(4) Analysis and utilization of instructor guides
(5) Utilization of lesson plans
(6) Appropriateness of instructional materials
(7) Quality control of instruction
(8) Student/instructor ratio
(9) Instructor capability
(10) Instructor productivity
(11) Instructor development program

METHOD

The method utilized was to assemble, study, and analyze related documents and printed materials such as training plans, Instructor Guides, orders, handbooks, plans of instruction, and the Catalog;[1] interview ANF instructors, unit chiefs, supervisors, and administrative personnel; administer and analyze instructor background survey; and observe presentation of instruction among 10 courses over a two-week period.

During the instructional observation period, instructors were asked what sources they used in developing their Lesson Plans or Instructor Guides. Training plans were examined for commonality and scope of content. Instructor Guides contained within Course Control Documents were examined for format, content, and adherence to provisions of Order No. AC 3000.18A.[2]

Interviews and direct observation formed the basis for findings on the utilization of Lesson Plans and appropriateness of instructional materials. Interviews with supervisors, instructors, and personnel of AC980, Evaluation and Standards staff, and a study of AC 3000.18A were used as the means to collect data on quality control of instruction.

Direct observation of conduct of instruction was used to collect data on student/instructor ratio. Both direct observation and analysis of a survey instrument were used for determining instructor capability. The instructor development program was assessed through study of the program of instruction for FAA Academy Instructors, the Supervisors and Instructors Guide, and the Job Training Standard for FAA Academy instructors.

[1] **Federal Aviation Administration Combined Agency Catalog.**

[2] **Federal Aviation Administration Academy Training Order No. AC 3000.18A, 18 November 1970, w/change 1, 27 April 1971.**

RESULTS AND DISCUSSION

USE OF JOB ANALYSES AND RELATED TECHNIQUES

A sample of the instructors who taught the lessons monitored in the 10 courses under study were asked what sources of information they used in writing their Lesson Plans, or Instructor Guides if, indeed, they had been involved in such activities. In no case did any instructor state he had used or even seen a maintenance concept. One instructor stated that he had participated in preparing a job analysis with SMS. The single source cited most often was the training plan. Other sources cited were: manufacturers' manual, schematic diagrams, the equipment, other instructors' presentations, standard electronics texts.

On the basis of the sample of instructors interviewed it is clear that Job Analysis documents play a minor role in the preparation of lesson material.

ANALYSIS OF TRAINING OBJECTIVES

The extent to which training plans are used in the preparation of instructional materials depends, in part, on the extent to which they *can* be used. That is, if training plans are to be used, they must contain the kinds of information necessary. Training objectives, for the purpose of this study, are taken to be synonymous with training outcomes.

The training plans for the 10 courses were studied with respect to the presence and character of three elements: Summary of Job Functions, Training Outcomes, Outline of Course. Although all three elements were present in the training plans for the 10 courses, they varied in character from one course to another, sometimes with an easily recognized rationale and at other times without one.

Summary of Job Functions. These summaries ranged in character from equipment-oriented specific skills and knowledges required (e.g., 9020) through a mix of equipment specific and general skills and knowledges (e.g., ATCBI-3) to not-equipment oriented statements when they probably should have been (e.g., ARTS III) and to non-equipment oriented when they understandably could not have been (SSF). The following list indicates the character of the summary of job functions for each course.

Course No.	Equipment Oriented	Comment
43413	Yes	
43411	Yes	
40210	Yes	
40216	Yes	
42002	No	Could have been equipment oriented
40318	Yes/No	A mixture of equipment and non-equipment associated statements
40200	No	Principles course
40115	No	Principles course
40001	No	Many equipments
40104	(no job summary)	

In the Diesel Engine Generator course, an analysis of performance in terms of knowledges and skills required substituted for a job summary.

The meaning of the statement "not-equipment oriented" as it was used to describe the summary of job functions for the ARTS III course will become clear through comparison with a related statement from the IBM 9020 summary of job functions.

IBM 9020
Course # 43413

c. Uses Specific Mechanical Knowledge and skills.

The CCC Technician will make precise adjustments, in accordance with maintenance specifications, to the mechanical portions of the following equipments:

(1) Magnetic Tape Drives
(2) High Speed Printers
(3) Card Readers
(4) Card Punches

ARTS IV
Course # 42002

f. Makes adjustments required to meet performance standards.

Thus the reference to specific equipments requiring precise adjustments led to the conclusion that this statement from the summary of Job Functions from the 9020 course was "equipment oriented." The lack of such specificity in the ARTS III statement led to the conclusion that it was "not-equipment oriented" by comparison.

The seven statements in the ARTS III summary are quite general, and contain no specific references to ARTS III equipments or components.

In general, the summary of job functions as a tool to determine what training is required is, of and by itself, inadequate for the purpose, even for those courses where the statements are equipment oriented and relatively specific. Because of the lack of detail and specificity in these statements, the door is wide open for course developers to include whatever content they feel can be justified to satisfy the requirement.

Training Outcomes. The training plans for the 10 courses were reviewed with respect to the training outcomes. Again, considerable variation in the character of the outcomes was evident, ranging from specific equipment-oriented outcomes to non-equipment specific, and again, in some cases understandably so, in others, not. The following list indicates the character of training outcomes for the 10 courses.

Course No.	Equipment Oriented	Comments
43413	Yes	
43411	Yes	
40200	No	Principles course
40115	No	Principles course
40001	No	Many equipments
40318	No	Could have been equipment oriented
40216	No	Could have equipment oriented

Course No.	Equipment Oriented	Comments
40210	No	Could have been equipment oriented
42002	No	Could have been equipment oriented
40104	No	Could have been equipment oriented

The training outcomes in the training plans indicate the state of such data at the time the training plans were approved, ranging in date from 1965 to 1971. It may be taken therefore that these training outcomes existed at the time the courses were developed.

Outline of Course. The outlines of the 10 courses were reviewed and again there was a considerable lack of consistency among them in terms of level of detail and allocation of time. In general, equipment courses tended to present their outlines in terms of subsystems of assemblies and allocated time to lectures and labs on that basis. TACAN, SSF, and CE used a topic approach.

It is clear from a study of the training plans that, were the training plan to be the sole guide for the development of course content, course developers would have very little guidance and great latitude.

AVAILABILITY OF TRAINING PLANS

As indicated earlier, training plans were available for all 10 courses. In structure they are quite similar; in content they differ markedly both in the type of material presented and in the degree of detail. Undoubtedly, part of the cause for this is the point in time when they were prepared, ranging in date from 1965 to 1971.

ANALYSIS AND UTILIZATION OF INSTRUCTOR GUIDES

The Academy is concerned with the control of content and presentation of course material. This is evidenced by the existence of paragraph 22d, Section 2, Development of Academy Course Control Documents, AC 3000.18A, FAA Academy Training. It states that the Instructor Guides should contain:

(1) Student outcomes
(2) Suggestions for achievement of outcomes
(3) Subject matter, or laboratory exercise outline, and depth of coverage
(4) Time allocation by lesson/laboratory
(5) References for use by instructor
(6) Training aids available

Paragraph 22e states that Lesson Plans, when approved by the supervisor and containing all the elements of Instructor Guides, may be identified as the Instructor Guide and submitted as "PART B" of the Academy Course Control document.

Examination of the hundreds of Lesson Plans or Instructor Guides for the 10 courses reveals a great disparity, not only between courses but even within courses, both as to format and to adherence to the provisions of AC 3000.18A.

Course No. 40318

- No suggestions on how outcomes can be achieved.

Course No. 40104

- No Lesson Plans or Instructor Guides. (Daily lecture outlines are substituted)
- Student outcomes specified only for first day.
- The time to be allocated to specific topics is not specified.
- No training aids are cited.

Course No. 40001

- No suggestions on how outcomes can be achieved.
- Transparencies are not indicated by identification number or topic.

Course No. 40210

- Transparencies are not indicated by identification number or topic.
- No suggestion on how outcomes can be achieved.

Course No. 43411

- Outcomes not identified as "student outcomes." as required by Instructor Guide format. (They are listed under objectives; but do not state what student will be able to do.)
- No suggestions on how outcomes can be achieved.

Course No. 43413

In this course, the Lesson Plans or Instructor Guides are characterized by great differences in format, not only with respect to other courses reviewed but also with respect to the various sections of the 9020 course itself. Even within a given section the Lesson Plans are likely to be in different formats.

Data Flow and Control

(1) Lessons 1-6:

- Do not conform to official format.
- Student outcomes not identified.
- No suggestions for achieving outcomes.
- Training aids not identified.

CE/IOCE

- Many lessons are hand written.
- Many do not contain student outcomes.
- Many do not specify the allocation of time to outcome.
- Many do not contain teaching references or notes.
- Some contain extensive text and pictorials reproduced from a commercial instruction manual.

System Utility and Diagnostic Programs

- Student outcomes not explicitly identified.
- No suggestions on how outcomes can be achieved.

System Operation and Programming

- Student outcomes not explicitly identified.
- Objectives often stated as directions to instructors.

System Console and PAM

- Lesson Plans are on "programmed lesson" forms, but content is not programmed.
- Student outcomes are missing.
- Time allocation not given.
- Training aid identification is variable.

Maintenance Features and I/O Devices

- Some Lesson Plans do not contain objectives.
- Some lessons do not show time allocation.

Storage and Channel

- No time allocation.
- Material organized by days and presented in lecture format.

In general, it is quite evident that the Instructor Guides, Lesson Plans, and so forth, for the 9020 course do not conform to the format or contain the information which AC 3000.18A would require were these documents to form a portion of the course Control Document.

Course No. 42002

- Instructor Guides are in neither of the approved formats.
- No specific identification of transparencies.
- No time allocation for completion of instructional block.

Course No. 40200

- "Lesson Guides" are in non-standard format.
- Visual aids are not explicitly identified.

Course No. 40115

- "Presentation lessons" depart from "programmed lessons," format prescribed by AC 3000.18A.
- Lesson outcomes are not specifically identified.

These findings give an indication of the wide range of formats with which so-called Instructor Guides have been prepared, and the wide range in content specificity that exists. The Academy's interest in obtaining content standardization and control over the presentation is obvious from the existence of AC 3000.18A, but it is evident that standardization does not exist.

Instructor Guides are used by instructors in preparing their personal Lesson Plans. They rarely are present in class, since instructors either lecture from memory or use their own Lesson Plans.

UTILIZATION OF LESSON PLANS

Order No. AC 3000.18A, paragraph 22e, defines a Lesson Plan as a document used by the instructor to present a lesson. It is the instructor's personal approach to accomplishing the lesson objective or outcomes. It includes methods, techniques, and training aids to be used in ensuring accomplishment of desired lesson outcomes. As indicated in the foregoing, the instructor uses the Lesson Plans during presentation.

During the period when the research team monitored presentations at the Academy, instructors were found to be using, for the most part, hand-written Lesson Plans they had personally prepared. In general, these Lesson Plans appeared to be tightly organized and content specific. In no case were student outcomes ever mentioned, and in no case were student outcomes ever observed to be on the Lesson Plan. Thus, even if student outcomes were available in the Instructor's Guide, there is no assurance that these outcomes would appear in the instructor's Lesson Plan. Indeed, there is no requirement in Paragraph 22e that Lesson Plans must contain a statement of student outcomes. It is only when Lesson Plans are to be identified as Instructor Guides and submitted as Part B of the Course Control Document that they must contain all the elements of the Instructor's Guide.

The main problem with not including student outcomes as part of the Lesson Plan is that if the instructor does not announce the outcomes to the class, the class never learns what is expected of them during that period of instruction. It was found that, at most, an instructor announces what content he expects to cover, rather than what students will be expected to be able to do.

Being the creation of an individual instructor, Lesson Plans are likely to be more or less detailed as a function of how much the instructor elects to keep in his head and how much he elects to commit to paper. Though an Instructor's Guide exists which prescribes the content to be discussed, it does not provide a detailed breakdown of time allocation to each part of the lesson. Therefore, individual instructors teaching the same material may devote different amounts of time to a given subject as a function of their interest or ability, thus leading to non-standardized presentations and lack of uniform emphasis.

APPROPRIATENESS OF INSTRUCTIONAL MATERIALS

Examination of Lesson Plans, Instructor Guides, Lesson Guides, Lectures, and direct observation of the presentation of instruction leads to the conclusion that the contents of such lessons and their presentation agree with the topics that are to be covered. That is, if a block of instruction is supposed to be devoted to explaining the theory of operation and tracing the circuits on schematic diagrams of a given piece of electronic equipment, both the organization and structure of the Lesson Plan/Instructor Guide and the actual presentation of this information in class are directed toward that topic.

The Lesson Plans are not appropriate in certain cases because some of the materials contain errors. Some of the errors had been known in advance by the instructor and others were detected by students in class. It is also the case that the Instructor Guides do not provide adequate indication of the actual or relative amount of time to devote to various subtopics within any given lesson. Lastly, they do not contain, in a directly useful way, material that instructors can use to decide whether student outcomes, have been achieved.

QUALITY CONTROL OF INSTRUCTION

Description of Present System

There are a number of ways in which attempts to control the quality of instruction have been made at the Academy. One method is described in Section 2 of AC 3000.18A—"Development of Academy Course Control Documents." The existence of this section documents the Academy's need and desire to formalize, standardize, and regulate course content.

Another element of the quality control of instruction is embodied in Section 3 of the same document—"FAA Academy Instruction Appraisal Program." It establishes a program for appraising instruction by examining both course content and instructor effectiveness.

Another component is described by Section 1 of Chapter 8—"Evaluation of Academy Conducted Courses by the Training Branches," another is in Section 2—"Evaluation by Students and their Supervisors through Questionnaires." An appraisal of the various quality control documents indicates that, in general, the burden of evaluating the performance of the individual instructor falls upon his immediate supervisor or Unit Chief, who is required to monitor his performance in a lecture or a laboratory situation at least once every six months. Forms used for recording observations on instructors may be of any type as long as they meet certain criteria indicated in

the Order No. AC 3000.18A, but AC Form 3030-4, Instructor Observation and Appraisal Record, Appendix 3, is recommended. The key elements of this form relate to the instructor's performance as an instructor, per se.

The monitoring procedure is straightforward. The observer arrives before class starts and makes observations of the instructor's performance for a period of at least two hours, or long enough for a lesson to be completed. After completing all items on the observation form, the observer discusses his findings with the instructor. These observations may include suggestions for improvement. Both the instructor and the observer initial the forms, and the records are then filed.

Chapter 8, Section 1, par 803 of AC 3000.18A, states in part: "Every resident course conducted by the FAA Academy shall be formally evaluated during the first class conducted, then at least once every three years according to the procedures prescribed in this chapter." Paragraph 805 details the procedures for formal evaluation of resident courses. The Training Plan, the Program of Instruction, and each element or phase of the course will be studied during the evaluation. In addition, questionnaires received from students and supervisors will be examined and compared with the findings resulting from monitoring. Paragraphs 805c and d refer to follow-up actions and the evaluation report.

Chapter 8, Section 2, outlines how courses are to be evaluated by students and their supervisors through questionnaires. Three types of questionnaires are identified—End-of-Course Student Questionnaire, Post-Course Graduate Questionnaire, and Supervisor's Questionnaire. In Paragraph 813b—Analysis and Reaction to Questionnaire Results—the following statement is made, "Evaluation and Conclusions should generally be made concerning the trends indicated from a number of questionnaires rather than from a single student's comments."

Finally, Section 3 of Chapter 8 deals with the evaluation by organizations other than the Training Branches. Within Paragraph 823—Background, recognition is made of the processes other than actual instruction which culminate in an effective and efficient training program. These would include planning, organization, and administering training programs as well as the supported services utilized. Under Paragraph 824—Policy, the statement is made that the evaluation and standards staff will conduct at least one formal evaluation per year for each training section of the Academy.

The evidence shows that the Academy is generally performing these quality control activities. For example, copies of Instructor Observation and Appraisal Records have been collected and reviewed. It is evident from the comments it contains that constructive criticism was made. It was also noted that evidence exists which indicates that students and their supervisors do complete the End-of-Course, Post-Course Graduate, and Supervisor's questionnaires. Further, the authors note that the Evaluation and Standards staff (AC 980) performs its function of evaluating other than instructional aspects of the programs as well as providing guidance to the school for the evaluation of programs by branch personnel.

Analysis of the System

In spite of the existence of well-organized and conceived quality control policies and procedures, it is concluded that an adequate quality control system is not in operation at the Academy. The reason is the absence of or ineffectiveness of one or more essential elements of a quality control system.

Smith[1] identifies the essential elements of a quality controlled system as (a) a detailed statement of training objectives based on job requirements; (b) accurate and appropriate proficiency measures; (c) effective communication concerning performance of

[1] R.G. Smith. *Controlling the Quality of Training*, HumRRO Technical Report 65-6, June 1965.

students on tests; (d) effective procedures for corrective action if necessary; (e) supervisory support. Curiously, most of the elements listed appear to be present in the FAA Academy, yet the quality control system does not appear to be working satisfactorily. Why should this be the case?

Consider the first of the elements Smith indicates as part of the quality control system—a detailed statement of training objectives based on job requirements. Training objectives appear and reappear in various guises in various FAA documents. For example, they appear in the FAA Academy Course Catalog as Training Outcomes. They appear in the Training Plan sometimes explicitly identified as Training Objectives. Training Plans even include a section devoted to a summary of job functions which, on the face of it, appears to be an attempt to indicate job requirements, granted that it is just a summary statement of job functions and not a complete job analysis.

If Training Objectives are explicitly and exclusively contained within the series of statements known as Training Outcomes which appear in the FAA Course Catalog they are, in fact, too general in nature to be useful as information upon which to base and derive training content. Unless the training objectives are known, and unless the training objectives are based on job requirements, it is not possible to develop accurate and appropriate proficiency measures, and unless such measures are developed there is no way of knowing whether the training objectives have or have not been met in training. Adequately detailed statements of training objectives based on job requirements do not appear to exist.

The Academy does use tests, and the tests are used to measure the students' progress through the courses. Tests may accurately and adequately measure students' achievement of the instruction as it is presented in the courses. However, unless those courses present material which is directly related to job requirements, there is no assurance that the mastery of the course contents means the student has mastered any part of the performance required on site.

From direct observation at the Academy it can be said that the primary use to which tests are put is in grading the trainee. There is a pool of test items of graded difficulty related to the same subject area which is available to instructors for the purpose of creating new versions of tests or to cover particular phases or portions of a course. Upon completion of such tests, the grades are determined and the ease index computed for that question for that administration of the test. These indices are then annotated on a record especially prepared for that test question. Over a period of time, success in the usages of a particular question builds a history with respect to the ease index.

But tests can be put to another use which apparently has not been employed by the Academy course personnel. If tests were designed so as to measure the ability of students to perform the job tasks for which they have been trained, then such tests can be used to modify the training program length. For example, if all or nearly all students can perform the task, then the training program is satisfactory or perhaps could be shortened to provide more time in other areas. On the other hand, if too many students cannot perform a task the training is ineffective and requires improvement.

If a large number of students are unable to perform a task upon being tested, the test should not be re-designed so as to test their ability to perform a different task. Assuming that the task on which they are being tested was derived from job requirements, the task itself is still valid. Such a result implies the need for a different set of tests called "diagnostic tests." These tests are designed to determine what part of the training program is not doing what it is supposed to be doing. That is, the tasks which are being tested are those which are built up of component skills and knowledges and subtasks. If mastery of the subtasks is a necessary and sufficient condition for the accomplishment of the whole task, then some one or several of the subtasks might not have been mastered by the students.

Diagnostic tests can identify portions of the course where improvements need to be made, such as increases in training time, identification of better methods for presentation of information, or removal of erroneous material. Diagnostic tests can pinpoint or highlight a specific area for attention. If a course had been in operation for some period of time and there appeared a sudden change in the ability of students to perform a task, the question arises as to what had occurred in this time frame that reasonably could have produced this event. It might have been a change of instructors, or a change in content, but, at any rate, the existence of the test materials and the test results can be used for making changes within the program itself. This particular aspect of quality control does not seem to have been a very important one for use by first-line supervisors.

Multiple-choice test items are very popular. One reason is that the scoring is objective; it requires only clerical skills or it can be done by machines. It is easy to develop data on the characteristics of the items, such as difficulty or relationship to total score. One major difficulty with a multiple-choice item is its lack of validity for testing certain kinds of skills and subject matter. A valid test item is one that requires the trainee to demonstrate that he can perform as required by the objective. It also requires performance to be demonstrated under conditions required by the objective and his score, according to standards of performance, required by the objective.

Smith has stated that the only type of training objective for which the multiple-choice item is directly suitable is one that requires a student to select from among several alternatives that are present on the job. Two examples would be: the selection of proper tools for a given purpose, and the selection of a proper procedure from among those described in a technical manual. Smith goes on to show that indirect validity of multiple-choice items can be determined, but they should be determined by an actual test. Smith provides a formula for conducting the test.

Concerning the Academy's utilization of test results, it should be noted that although the charting of trends was said to be done by certain Unit Chiefs, none of those interviewed was able to produce an example of such a chart.

Accuracy of Instructional Materials

Still another area of interest in the quality of instruction is that of the accuracy of instructional materials. During the period of observation, there were numerous instances where course materials—graphs, handouts, visuals, and projectuals—were observed either by the student or by the instructor to be in error. Appropriate notations were made at the time in the student guides or student handouts and the matter forgotten.

It was of interest to determine what policies and procedures were being used to ensure that course materials were corrected and brought up to date as needed. Instructors are responsible for seeing that errors detected in instructional materials are corrected on the Masters. They are expected to bring the matter to the attention of his Unit Chief who will see to it that the notation is placed on or with the Master for the instructional material so that when the next printing of the material is arranged, they will be updated and corrected before the printing is accomplished.

The effort required to re-do Masters and reprint and insert changes in the instructional material each time an error is detected is probably not economically justifiable, although the present process permits the accumulation of a number of corrections to be made on the same page over a period of time prior to reproduction of the next set of materials. Nonetheless, the practice of students correcting materials upon direction by the instructor may undermine student confidence in the overall accuracy of the materials.

STUDENT/INSTRUCTOR RATIO

Student/instructor ratios are variable and depend upon both the content which is being taught or presented and the method used to present it. In the 10 courses observed, the lecture method was dominant in the presentation of classroom material. The ratios ranged from 7 to 1 in the DF Course (No. 40104) to 19 to 1 in the Solid State Fundamentals Course (No. 40115). However, for the purposes of the Academy, student/instructor ratios in lectures can be increased. In other instructional settings, lectures are frequently presented to several hundreds of students. It is well known that lectures can be presented by television to an unlimited number of students.

The physical size of classroom space and the requirement for tables upon which students spread their materials is a major limiting factor in the number of students that can be accommodated by the lecture method. Another limitation on the use of the lecture method is the degree of interaction which exists between instructor and students. If, because of lack of clarity of the presentation, numerous questions are raised by students, the instructor may be unable to complete presentation of the material within the time allotted. The larger the number of students in a class in which such is the case the higher the probability of consuming excessive amounts of time in clarifying points.

The laboratories, generally but not always, had two instructors present. Two instructors were present for all courses except the laboratory for the ARTS III, laboratories for VHF/UHF DF and one laboratory of the Wilcox Mark I ILS. The laboratory observed in the ARTS III was actually a demonstration, and because of equipment limitations only one instructor could effectively be used to present his demonstration to a group of four students. The Mark I ILS laboratory in which only one instructor was used could have profited from the use of another instructor since coordination of student activities inside and outside the building was required. In the DF Course, since there were only seven students in the class, only one instructor was used.

The problem of determining the correct student/instructor ratio for laboratories is complicated by the requirement to identify what the student and instructors are expected to do in the laboratory. Students are generally provided with explicit instructions on how to perform the laboratory exercise or experiment. However, since standards of performance in terms of speed and accuracy have not been identified and used in the design and administration of the laboratories, the laboratories are not used for the purpose of developing proficiency in performing tasks. Even in those cases where students perform adjustments or alignments based on or identical to those contained within official SMS documents, students usually work in groups of at least two and sometimes three. Therefore, each student has relatively little opportunity to perform the procedure, much less to master it, even if standards of proficiency were available.

For the laboratories observed, the laboratory guides for the most part, were prepared in sufficient detail as to enable the students to perform the laboratory work without help from the instructor. This was clearly the case in the TACAN Principles course and the Solid State Fundamentals course. With the ATCBI-3, on the other hand, both laboratory instructors were heavily engaged in actively guiding the progress of the students through the exercise by providing pacing for the conduct of the experiment, knowledge of results, and interpretations or inferences to be drawn from their observations. Even in this case, since students worked on the experiment as a group, the benefit to the individual student depended upon the role he played within the group.

In the fundamentals courses it was clear that the role played by the instructors was that of a monitor—that is, to observe and assure that students were working actively toward the goals of the experiment and to render assistance when requested.

In general, if the instructor provides students with timely examination and criticism of their performance during the laboratory, he can become very quickly overloaded with

more than two students to observe and attend to simultaneously. If his role is primarily that of a monitor and the activities the students are to undertake are sufficiently well structured and carried in a written material format, then the number he can effectively supervise and monitor increases rapidly.

In the laboratories observed the student/instructor ratios appeared to be appropriate for the manner in which the laboratories were conducted. Were the laboratories to be redesigned so as to achieve a specified level of skill in performing particular tasks, the average student/instructor ratio for laboratories would probably decrease markedly but the exact number would depend upon the nature and structure of the redesigned lab.

INSTRUCTOR CAPABILITY

During the instructional observation period the opportunity to observe the performance of instructors, both in lecture and laboratories, was presented. On the whole, instructors were free from petty but irritating instructional practices—that is, they did not mumble, speak to their chalkboard, or pace aimlessly about. They had no irritating mannerisms, and spoke clearly, distinctly, and loudly enough. Their writing was legible on the chalkboard. They appeared to be in command of their subject matter, were enthusiastic in presenting it, were generally able to field questions from students effectively, had the necessary materials available to them, brought them into play at the right time, and correctly used Vugraphs and visuals. Increased use of Vugraphs and visuals would be desirable. In addition, instructors could profit from some additional training in the selection of appropriate materials for presentation in the visual aid form.

Instructors were never observed to state what the student outcomes were for that particular lesson, and when a statement was made as to the scope of the lecture it was generally given in a cursory manner, verbally, or was placed on the chalkboard in the form of a series of topics. It is unknown whether students are provided with an outline indicating the coverage of each lesson and anticipated student outcomes. If they are not, it would seem advisable to construct such and have them for the students at the start of each lesson. In summary, on the average, instructors are judged to be capable of performing their role and do so in an acceptable manner.

Typical Instructor

Based on data collected from 58 instructors in the 10 courses under study a composite picture of a "typical instructor" can be sketched. He is a man in his early 40s whose formal education extends two years beyond High School. He holds a GS-12 Civil Service rating. He has attended approximately one year of formal FAA technical training courses; has also received technical training from other sources—military and civilian—each contributing about eight months to his technical training. He has received approximately five weeks of instructor training in the FAA and approximately three weeks of combined instructor training from the military and other sources. He has had more than six years of FAA maintenance experience, about three years of military maintenance experience, about two years of experience in other non-military or FAA activities, and about three years experience maintaining the equipment he is now teaching. He has had about six years' experience teaching for the FAA, and about half a year's experience teaching for the military or in other situations. Finally, he has had approximately three years' experience teaching in his current job.

In summary, the average instructor is a man in his early forties who has had substantial maintenance and instructor experience with relatively little instructor training. Instructors vary greatly in their individual characteristics as discussed later.

Instructor Background

During the period 4-15 July, Instructor background questionnaires were completed by instructors in the 10 courses under study who were available at that time. A copy of the questionnaire may be found in Appendix B. The data from those questionnaires were summarized and may be found in Table 6. Responses from 58 instructors were obtained. The mean and ranges were calculated, when appropriate, for the instructors in each course.

Age. In seven of the 10 courses, the mean age was in excess of 40. For the other three, the mean age was in excess of 35 years. Overall, the ages ranged from 31 to 57. It may thus be stated that the instructor staff is composed of mature men.

Civil Service Grade. Fifty-five instructors were at grade GS-12, the other three were GS-11; 40 instructors were classified as 855s; 11 were classified as 856s; 4 as 802s; 1 as 850; and 2 not specifically identifiable.

Formal Education. The mean years of formal education among the instructors in six courses were 14, or two beyond high school. For three other courses it was 13, and for the remaining course it was 12. Of the 58 instructors surveyed, six reported earning a college degree at the baccalaureate level, with none reporting an advanced degree.

Technical Training. The technical training questions sought to determine the total number of weeks of technical training each instructor had experienced in FAA courses, military training programs, and other (such as trade school, correspondence course). For nine of the 10 courses, instructors had undergone FAA-conducted training (in a variety of programs) which, on the average, exceeded 26 weeks. For the tenth course, instructors accomplished an average of 16 weeks' formal technical training (Diesel Engine Generators). The military technical training programs instructors reported attending accounted for considerably less of their formal technical training, on the average, than did the FAA technical training. Exceptions to this appeared in the ATCBI-3 and Communications Equipments for which instructors reported military training times in excess of FAA training. In general, other sources of technical training played a less significant part than either military or FAA technical training.

Instructor Training. The questionnaire sought to determine how many weeks of instruction each instructor had received which was designed to help him become or improve his skills as an instructor and the source of that training. Of the 58 instructors queried, only two reported not having undergone any FAA-conducted instructor training programs. Of those two, one had undergone a military instructor's training program, but the other had not. Seven of the 10 courses reported means of from 3 to 5 weeks of instructor training; two more reported means of eight weeks, while the tenth reported a mean of 17 weeks. Instructor training received under military auspices accounted for an insignificant amount of the whole. Analysis of these data clearly indicates that instructor training provided by the FAA accounts for the vast majority of such training for the instructors queried.

Maintenance Experience. By far the great majority of respondents indicated that their maintenance experience was in the electronic maintenance area. Eleven cited experience in electrical maintenance, eight in mechanical maintenance, and 14 across several types. The means, in terms of months of FAA maintenance experience among the 10 courses, ranged from 16 to 141 months, with 9 of the 10 courses reporting experience for the FAA in excess of 50 months. On the whole, military maintenance experience was considerably less. Of the 10 courses, nine reported means ranging from 15 months to 59 months. The tenth course, Diesel Engines, reported no military maintenance experience. Data on maintenance experience instructors had acquired in other than FAA or military situations were also obtained. In general, the means here were less than the experience reported with the FAA, but were quite variable with respect to military experience.

Table 6

Instructor Background Summary

Course No.	Short Title	No. of Instructors Surveyed		Age 1	Formal Educa. (Yrs) 2	Technical Training FAA 3	Technical Training (Wks) MIL 4	Technical Training Other 5	Instructor Training FAA 6	Instructor Training (Wks) MIL 7	Instructor Training Other 8	Maintenance Experience FAA 9	Maintenance Experience (Mos) MIL 10	Maintenance Experience Other 11	Exp. Maint. Equip. Teaching MOS. 12	Instructor Experience FAA 13	Instructor Experience (Mos) MIL 14	Instructor Experience Other 15	Exp. Teaching Current Job MOS. 16
40001	CE	7	Mean	45	13	33	45	42	3	0	2	94	28	29	49	65	10	18	47
			Range	33-58	12-15	18-73	0-208	0-229	2-6	0-3	0-12	0-276	0-72	0-132	0-80	0-144	0-24	0-84	0-144
40210	DF	3	Mean	43	14	28	22	5	4	0	0	86	53	15	83	144	4	0	14
			Range	33-54	13-16	16-47	17-26	0-8	2-6	0	0	0-120	38-72	8-24	0-208	51-296	0-13	0	12-158
40104	DEG	4	Mean	50	12	16	2	94	17	2	4	141	0	0	129	28	0	0	83
			Range	44-56	12-13	15-18	0-6	1-340	3-25	0-6	0-10	24-300	0	0	44-276	3-96	0	0	8-120
40115	SSF	4	Mean	44	14	46	28	18	8	1	17	72	16	14	112	51	0	0	55
			Range	40-47	12-15	22-69	0-79	0-35	½-25	0-4	0-52	54-90	0-30	0-24	0-336	6-132	0	0	24-100
40200	TACAN	5	Mean	45	14	56	17	52	3	1	3	138	24	50	17	72	7	5	74
			Range	34-56	13-16	40-76	0-39	0-208	2-5	0-6	1-14	42-264	0-48	0-120	2-36	12-132	0-36	0-24	12-132
40216	WILCOX	5	Mean	43	14	45	22	2	5	0	2	16	59	15	0	116	5	8	50
			Range	33-57	11-17	20-73	0-52	0-8	3-6	0	0-9	0-48	9-144	0-60	0	50-156	0-24	0-36	12-132
42002	ARTS III	9	Mean	37	13	65	32	46	5	2	0	67	39	24	0	69	11	0	4
			Range	31-43	12-16	39-107	0-78	14-104	0-10	0-16	0-4	24-168	0-108	0-72	0-3	1-154	0-48	0	1-7
40318	ATCBI-3	5	Mean	39	13	33	109	2	3	0	0	56	50	0	49	55	12	19	69
			Range	28-49	12-14	25-39	36-212	0-11	2-3	0-3	0	18-108	48-84	0	12-96	19-156	0-60	0-84	4-154
43411	I/O	4	Mean	36	14	63	17	22	5	1	0	88	15	14	0	61	5	0	25
			Range	31-42	13-15	50-76	0-32	0-59	3-8	0-4	0-¾	36-144	0-36	0-48	0	38-114	0-18	0	2-46
43413	9020	12	Mean	42	14	77	36	42	8	0	2	70	38	53	6	69	5	3	31
			Range	34-55	12-17	12-118	11-114	0-192	0-60	0	0-8	0-156	0-90	0-240	0-23	10-156	0-24	0-36	2-72

Experience Maintaining Equipment Instructor Now Teaches. Since it is commonly believed that such experience would be beneficial, it was of interest to learn how much time instructors had spent actually maintaining the equipment they were teaching. Seven of the 10 courses reported means ranging from 6 to 129 months. Three courses—WILCOX MARK I ILS, ARTS III, and I/O for Technicians—reported no experience maintaining the equipment. Both the TACAN Principles Course and the Solid State Fundamentals Course reported experience maintaining the equipment. The interpretation of this fact is that instructors reported number of months maintaining TACAN equipment and equipment containing solid state devices, even though the courses themselves are not equipment specific.

Instructor Experience. Data on the number of months of teaching experience for the FAA show that for the 10 courses, the means ranged from 28 to 144 months. Data on the number of months' experience teaching in the military or other situation show that by far the greatest amount of instructional experience was obtained in the FAA.

Experience Teaching in Current Job. Since it was possible that some instructors had had several tours of duty at the Academy, it was desirable to learn how long they had served as instructors in their current job. The means for the 10 courses ranged from 4 months to 83 months. For 8 of the 10 courses, the means were 25 months or over.

Teaching Aids

Supervisors and Instructors Guide,[1] is available to all instructors. This brochure has two sections—one on philosophy and policy and the other on instructional techniques. It is well organized, clearly written, and provides background information and specific guidance on pedagogical principles and techniques. Mastery and application of the contents of this brochure cannot help but improve the capability of instructors.

There is also, *A Program of Instruction for Instructor Training*[2]. Almost all of the instructors surveyed in the 10 courses reported having attended an instructor training program. Detailed comments on this program of instruction for instructor training are deferred to a later section on instructor development program. For the moment, it is appropriate to comment that the structure of the two-week program, if tied effectively to the FAA brochure mentioned, should provide a reasonably effective and sound basis for developing instructor capability.

INSTRUCTOR PRODUCTIVITY

The evaluation of instructor productivity depends on the selection of measures of productivity. No clear-cut measures of instructor productivity were found at the FAA Academy. This question was addressed by determining the tangible results obtaining from time invested by instructors in certain activities. Man-hour accounting for the instructors in the courses under study was obtained which showed the actual number of hours expended by instructors toward contact, preparation, writing, and a number of administrative and personnel categories. If it were known what tangible products resulted from a given instructor's expenditure of hours toward writing, for example, it would be possible to make a comparison of productivity within and among the various courses.

Accordingly, a request was made to the Academy to supply information revealing the total number of hours of lessons produced, the number of hours of lessons produced

[1] Federal Aviation Administration Aeronautical Center, FAA Academy. *Supervisors and Instructors Guide*, 1969.

[2] Federal Aviation Administration, Training Development Division, FAA Academy. *A Program of Instruction for Instructor Training*, January 1963.

per course, the number of times and date when a given lesson had been revised, and the frequency and date when the training plan was revised as a function of the magnitude of lesson plan revisions. ANF was unable to provide this information. Instead, ANF provided the actual record of the Instructor Activity Report for each of the employees requested. These reports do not provide the data needed and, as a consequence, it was concluded that if data are maintained which reflect the actual amount of work performed by instructors, it is of such form that its effectiveness can not be evaluated.

INSTRUCTOR DEVELOPMENT PROGRAM

Three documents were acquired and studied in the examination and evaluation of the instructor development program. They were:

(1) "A Program of Instruction for Instructor Training,"[1] Training Development Division, FAA Academy, Oklahoma City, Oklahoma, January 1963.

(2) Supervisors and Instructors Guide, brochure prepared by ANF Branch, FAA Academy, 1969.

(3) Job Training Standard for FAA Academy Instructors, 1971.[2]

These documents were reviewed to evaluate the scope and pertinency of the instructor development program as to organization and content, recognition of accepted principles of human learning, and a practical orientation to methods and techniques for accomplishing the instructional function.

There are 14 courses listed in the FAA Catalog under the general heading of Instructor Training and Development. Of these 14, two are pending approval. Of the remaining 12, three are conducted by the Civil Service Commission, leaving a total of nine FAA-approved courses. Two of the available courses—Course No. 10505, Written Achievement Testing, and No. 10509, Instructional Evaluation—cite Course No. 10500, or equivalent, as prerequisite. There are no formal course prerequisites for any of the other courses.

FAA Order No. AC-3000.18A, FAA Academy Training, Section 2, Paragraph 213B, states that each training branch of the FAA Academy will insure that its new instructors complete the "Basic Instructor Training" course prior to assignment to instructor duties. In addition, Paragraph 213C states that each new instructor shall complete the appropriate "Advanced Instructor Training" course within 12 months after beginning first classroom teaching assignment.

In addition, a Job Training Standard for FAA Academy instructors, dated February 1971, identifies the following as training courses:—Basic Instructor Training, Advanced Instructor Training, Curriculum Development, Testing Training. However, no specific course number identification is provided within the Job Training Standard. Moreover, examination of the June 1971 edition of the FAA Course Catalog identifies neither a "Basic Instructor Training" course nor an "Advanced Instructor Training" course. There is a Curriculum Development Course, No. 10507, which requires as a prerequisite that the applicant be a qualified instructor or equivalent, and a course called Written Achievement Testing, No. 10505, which is the testing course referenced in the Job Standard.

However, "Advanced Instructor Training" is not explicitly identified in the course catalog. Therefore, Order No. AC-3000.18A and the Job Training Standard for FAA Academy instructors notwithstanding, the connection between "Advanced Instructor Training" and one of the courses offered by the Academy for this purpose is not

[1] This document identifies the program of instruction as Course 1-C-1; however, the FAA Academy Combined Course Catalog, dated 15 June 1971 indicates that Course 1-C-1 is now identified as Course 10500.

[2] Federal Aviation Administration. *Job Training Standard for FAA Academy Instructors*, 1971.

specified. Nonetheless, the reference cited in No. AC-3000.18A sets forth the requirements for formal training by a new instructor to teach at the FAA Academy.

It should be recognized, however, that the published catalog lags the actual state of training program availability. Moreover, the need for information on the availability of instructor training programs exists at the Academy where the courses are taught. Hence there should be no difficulty in identifying the courses required since both the students and the courses are colocated.

Examination of the Program of Instruction for Instructor Training supplied and the Job Training Standard reveals a comprehensive effort to address the main performances to be expected from an instructor and indicates an alert awareness to modern concepts and procedures.

Indeed, by direct observation of the conduct of lectures and labs, and the generally acceptable conduct of instructors who taught in those courses observed, the conclusion is reached that the Course Instructor Development Program is at least effective to the extent that grossly irritating and obviously ineffective practices are not observable among the instructional staff. The degree of detail included in the duties, tasks, and subtasks columns of the Job Standard indicates professional attention to the identification of the knowledge and performance factors for instructors.

Consequently, it is concluded that the Instructor Development Program, as revealed by the aforementioned documents, addresses the relevant topics and should provide the necessary preparation for the instructor to perform effectively. He would be likely to perform more effectively were the system able to provide the basis for more adequate supervision, through greater specification of behavioral outcomes, student performance criteria, feedback on performance, and other quality control measures.

INSTRUCTIONAL OBSERVATION SUMMARY

During the period 9 through 20 August, laboratories, lectures and examinations were observed at the FAA Academy. Table 7 indicates how many hours of each type were observed for each of the 10 courses under study.

Table 7

Instructional Observation Periods by Course

Course No.	Short Title	Hours Observed			Total
		Lecture	Lab	Exam	
40001	CE	4	4		8
40210	VHF/UHF DF	4	4		8
43411	I/O	2	2	2	6
43413	9020	6	2		8
40200	TACAN	2	2		4
40216	Wilcox	4	2		6
40104	DEG	4	4		8
40115	SSF	4	4		8
40318	ATCBI-3	4	4		8
42002	ARTS III	6	2		8
		40	30	2	72

In scheduling observations an attempt was made to select an equal amount of lecture and laboratory time for each of the 10 courses. A second objective was to select laboratories directly related to the subject matter of an immediately preceding lecture. While it was possible to accomplish this latter objective for some courses, it became increasingly difficult to do so as additional selections were made because of scheduling problems. In addition, planning, administrative matters, and discussions with managers on related topics made it impossible to monitor all courses equally.

The monitor's observations were recorded on data collection forms during the presentation of instruction. Afterwards, these data were summarized and entered onto the forms which appear in Appendix A as Instruction Observation Data. These data sheets cover each period of observation. For each course, a summary of findings was prepared and is included herewith.

The purpose of this section is to present an overall summary, to the extent that this is possible, and provide an overall view of the findings insofar as they appear to be generalizable across all 10 courses.

The Academy had no prior knowledge of which lessons in the 10 courses would be monitored. Final scheduling decisions were made on 9 August at the Academy. It is reasonably certain that the conditions observed were representative of what would have occurred had the observer not been present.

The following observations apply to all 10 courses. The reader is referred to Appendix A for observations relevant to specific courses, and periods of observation.

(1) In general, printed formal lesson plans, or Instructor Guides—even when they exist—are not used by the instructor in presenting lectures. Rather, instructors typically speak from personal notes or from memory. The pitfall here is that successive presentations of the same lesson by different instructors are likely to contain different content. Thus, standardization and control of content presentation becomes impossible. Moreover, administrators have no reliable way of knowing what is being taught unless they monitor the lesson.

(2) Formal lesson plans or Instructor Guides rarely identify the visuals to be used in the presentation. Although the instructional staff may be able to identify these visuals, administrators cannot without direct contact with instructors or unit chiefs. This makes it difficult to review the appropriateness or quality of the visual.

(3) Formal lesson plans do not indicate the relative time weighting to be applied to the various topics, which can result in variability of presentation time—even if the lesson guide were to be followed.

(4) Student outcomes have not been identified for all lesson plans. Instructors typically ignore the student outcomes by not stating them or making students aware that they are expected to be achieved. Moreover, student outcomes are in terms that can be interpreted as instructions to the instructor.

(5) The only attempt observed (in courses other than SSF) to determine that student outcomes had been achieved was the instructor's question: "Are there any questions?" No attempt was ever observed whereby students were asked to show that they had achieved the desired outcomes. To defer assessing student's achievement of outcomes to a quiz or written exam is to lose the opportunity to clarify the point in the context of the lesson when everyone may benefit from it.

(6) There is insufficient emphasis placed on maintenance during lectures. Since the students are technicians who will ultimately be responsible for the maintenance of equipment or systems, every opportunity should be taken to relate the topic under discussion to maintenance. For example, if the topic under discussion consists of tracing the signal flow through a schematic diagram, some time should be devoted to deducing which parts could have caused a stated out-of-tolerance condition.

(7) Laboratory exercises appear to be well structured. However, their performance by students is not always accomplished close enough in time to the related lecture period. In part, this appears to be due to permitting students to work at their own pace. In general, laboratory instructors do not work closely enough with students. More laboratory instructors would facilitate closer working relationships and tighter control of lab time. It would also permit instructors to show the relationship of the lab to the lecture. As presently structured, some laboratory exercises should be converted into demonstrations utilizing slide/tape or TV tape.

(8) Significant reductions in course length could probably be effected, specifically in courses No. 43413, and No. 43411, by reducing time allocated to tracing logic on ALDs to individual logic elements, if, as appears to be the case, in maintenance the task is to locate the card containing the faulty logic element and perform repair by replacement of the card.

(9) Errors in course materials should be corrected and potential and real safety hazards identified and eliminated.

(10) In general, the lack of uniformity in format and character of content in course control documents makes it extremely difficult for training managers above the unit of section chief level to use them in making analyses for training improvement purposes.

Comments with respect to each course are summarized in Table 8.

Table 8

SUMMARY OF INSTRUCTIONAL OBSERVATIONS

Course No. 40001, CE

Although lesson plan is available, instructor speaks from notes. Student outcomes should be stated, and attempts made to determine that students have achieved them. Closer interaction of instructor with students in laboratory is required.

Course No. 40210, VHF/UHF DF

Although lesson plan was available, instructor spoke from notes, made no references to objectives and did not attempt to assess student achievement of same. A greater emphasis on maintenance is desirable. The laboratory could profit from a closer interaction between students and instructor. The laboratory exam should reduce the weight allocated to use of test equipment and clean-up.

Course No. 43411, I/O for Technicians

Since lab briefing is not given prior to each lab, Instructor Guide is not present but available. Students work on different labs according to their own pace. If working on same lab, instructor could emphasize points in common. As is, he must monitor progress on variety of exercises simultaneously.

Greater emphasis should be placed on maintenance aspects during lectures, and assessment of student achievement of instructional objectives. Attempts to prepare students to isolate to individual logic element appear not to be supportable by configuration of hardware.

(Continued)

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A STUDY OF TRAINING PROGRAM IMPROVEMENTS. VOLUME I. FINDINGS AN--ETC(U)
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Course No. 43413, 9020 CCC

Lesson plans should be revised to include statement of unit student outcomes, and time allocation to major portions of lessons. Instructors should assess student progress toward outcomes by requiring demonstration of mastery of content. Essentially procedural content should be placed in a procedural format. Laboratory exercises which are essentially demonstrations should be converted to demonstrations. Student proficiency in use of ALDs and FLTs should be developed to criterion standards early, and excessive ALD usage eliminated. ALDs are specific for each 9020 installation; skill in using ALDs is required, but specific knowledge of Academy ALD is not required for field use.

Course No. 40200, TACAN Principles

Instructor should state and assess student achievement of student outcomes. Greater emphasis should be placed on the maintenance aspects. Greater supervision and direction of students in laboratory desirable.

Course No. 40216, Wilcox

Lesson plans should be written for this course, stating outcomes required. Instructors should attempt to determine that outcomes have been achieved. Greater maintenance emphasis should be made. Equipment performance tests should be constructed and used. Potential safety hazards avoided.

Course No. 40104, Diesel Engine Generators

Lesson plans should be developed to include student outcomes. Course materials need correction. Increase emphasis on maintenance aspects. Closer monitoring of student performance in laboratories required; and more attempts should be made to assess state of student's knowledge during lectures. Awareness of and attention to potential safety hazards should be stressed.

Course No. 40115, SSF

Although the course is taught from a "programed text," lesson plans should be developed to include student outcomes. An additional set of questions for use with the responder in class should be prepared permitting incorporating test answers to present questions for use in "home study." Laboratories should be better time-phased with lecture portion; closer supervision of progress in lab is required.

Course No. 40318, ATCBI-3

Lesson plans are too brief, really only a topic outline. Instructors should attempt to determine that students have achieved the outcomes desired. Greater emphasis should be given to maintenance orientation . . . how to apply the knowledge. Waveform guides would be desirable in conduct of laboratories. Some laboratories could be converted into demonstrations and still achieve the actual effect now being achieved.

Course No. 42002, ARTS III

Formal lesson plans need to be prepared for this course, with student outcomes stated. Emphasis needs to be placed on how the knowledges presented in lectures apply to maintenance activities. Instructors should determine that students have learned through requiring them to demonstrate their state of knowledge. Course materials should be corrected. Potential exists for converting some laboratory time into demonstrations using other than equipment as medium.

SUMMARY OF EVALUATION OF INSTRUCTIONAL PROGRAM

1. Use of Job Analyses and related techniques
   a. Job Analysis documents play a minor role in preparation of lesson materials.
   b. Instructors do not use maintenance concepts to prepare lesson plans or Instructor Guides.
   c. Instructors occasionally use job analysis documents to prepare lesson plans.
   d. Principal sources used by instructors: Training plans, manufacturers manuals, equipment, other instructor's presentations, standard texts.
2. Analysis of Training Objectives
   a. Training plans provide too much latitude and insufficient guidance to be effective for the development of course content.
   b. Summary of Job Functions were not uniformly equipment oriented.
   c. Training Outcomes were not uniformly equipment oriented.
   d. Course Outlines were inconsistent in terms of level of detail and allocation of time.
3. Availability of Training Plans
   a. Training plans were available.
   b. Training plans vary enormously in level of detail and type of material presented.
4. Analysis and Utilization of Instructor Guides
   a. Instructor Guides vary greatly from course to course and within a course as to format, content and adherence to provisions of AC 3000.18A.
   b. Instructor Guides give no indication of performance levels required of students.
   c. Instructor Guides do not prescribe time distribution within lesson.
   d. Instructor Guides serve to guide instructor in preparing his lesson plans.
5. Utilization of Lesson Plans
   a. Instructors use handwritten or typed notes as lesson plans.
   b. Lesson plans contain no student outcomes.
   c. As personal creation of individual instructor, lesson plans are likely to differ from one instructor to another, encouraging non-standardization of presentation.
6. Appropriateness of Instructional Materials
   a. Materials are appropriate to content presented.
   b. Materials contain errors.
   c. Materials do not contain means for determining if students have achieved outcomes of lesson.
7. Quality Control of Instruction
   a. Characteristics of quality control system exist.
   b. Accurate and appropriate proficiency measures on tasks to be trained on are missing.
   c. Detailed statements of training objectives based on job requirements are missing.
   d. Accuracy of instructional materials needs improvement.
8. Student Instructor Ratio
   a. Lecture ratios are adequate.
   b. Laboratory ratios are adequate as laboratories are currently structured.
9. Instructor Capability
   a. Instructors are generally competent.
   b. Instructors do not interact with students in laboratories sufficiently.
   c. Instructors do not determine that students have achieved outcomes required.
10. Instructor Productivity
    a. No clear cut definitive measures of productivity were found.
    b. No data is available to show what products resulted from writing time expenditure.
11. Instructor Development Program
    a. Formal instructor training programs address relevant topics to prepare instructors to perform effectively.

Chapter 4

STUDY AND EVALUATION OF ACADEMY EQUIPMENT REQUIREMENTS (TASK C)

OBJECTIVE

This task was concerned with a study of criteria and standards governing the purchase and installation of equipment to determine whether the process is responsive to Maintenance Concepts and training outcomes required, and is cost-effective.

METHOD

Relevant official documents were studied and knowledgeable FAA officials were interviewed. An analysis was made of the need for equipment to satisfy training outcomes listed for the courses for which maintenance concepts were provided. In addition, the function and utilization of equipment were examined with respect to the appropriateness of the equipment for meeting the training outcomes required. This examination was achieved by a study of the course control documentation and by on-site observations of resident training. Finally, interviews with managers, supervisors, trainers, and trainees at four operating sites were used to acquire additional information on the advantages and disadvantages of using operating equipment at field sites in the context of their OJT operations.

DISCUSSION

CRITERIA AND STANDARDS FOR PURCHASE AND INSTALLATION OF EQUIPMENT

The stated purpose of FAA Order No. 3000.8A[1] is to establish FAA policy for the scheduling and funding of new types of equipment and facilities for agency training programs. As a statement of policy, it sets forth the objective of including, as part of the program proposal, the identification of necessary equipment for use in FAA training programs, the priority of delivery schedule, and whether or not equipment or parts thereof can be installed in an operational location when replacement training phase begins. In addition, it sets forth responsibilities of the operating services in connection with the order. It does not, however, discuss the criteria and standards to be used in implementing the intent of the policy.

Consultation with FAA training officials disclosed that there is no official documentation prescribing the procedures for implementing Order No. 3000.8A. There are no

[1] Federal Aviation Administration. *New Equipment and Facilities for Training*, FAA Order No. 3000.8A, 28 June 1968.

standardized forms or formats for use in analyzing equipment purchase problems. There are, therefore, no official published standards and criteria governing the purchase and installation of equipment.

Nonetheless, equipments are purchased and installed at the Academy for maintenance training purposes. Because there are no formal official documented procedures for performing this function, the decisions are made on the basis of analyses by personnel experienced in performing them in an informal way. The following discussion describes some of the factors taken into account in making these decisions and is presented as an effort toward understanding how the decisions may be made. Since the description is based on an interview with one analyst who drew upon his experience in performing this function, and since there are no formal checklists or procedures, the description should be taken only with reservation.

The maintenance concept document, as such, is not utilized or referred to by the analyst. Although the Training Proposal is utilized, Training Outcomes are not. Every question relating to the purchase of equipment is treated as an individual case. Factors taken into consideration include:

A. The number of equipments or systems to be purchased.
B. The rate of delivery of the systems to the field.
C. The installation and check-out period.
D. The number of installation technicians or engineers needing training.
E. The number of maintenance engineering or support personnel needing training.

From these factors the number of people to be trained are determined. Although FAA Handbook No. 3000.6A[1] states in Paragraph 303, "training proposals may originate from any segment of the agency," the analyst interviewed stated that the System Maintenance Service develops the Training Proposal. In any event, on the basis of the factors cited above and interaction with SMS, the data contained in the Training Proposal and the Academy, a determination is made as to whether the Academy can perform the training, and when.

There are a number of possible solutions to the question of providing equipment for training purposes at the Academy. In some cases equipment need not be provided because it already is available. When the projected training requirements are initially large and are expected to decrease later, one method sometimes used is to divert the first system to be manufactured to the Academy on loan. That system is then used at the Academy for training while the other systems are sent to sites. After all the systems have been installed at the site, the borrowed system is sent to a site for installation. Training thereafter is done on site or with directed study OJT packages. When a continuing need for training at the Academy is foreseen, equipment may be requested for permanent installation. If more than one piece is needed because of a large requirement for initial training, a permanent system may be requested and another one obtained on loan.

At present, there is no formal procedure by which Academy personnel are required to analyze new equipment with a view to determining whether similar equipment already installed at the Academy is sufficiently similar to be used for training without the purchase or loan of one or more of the new equipments. When such studies are made they are done informally.

A 1969 study of the Academy training costs indicated that the average cost per student week was $175. Taking into account inflationary trends, the present estimated cost for Academy training used at headquarters is between $200 and $225 per student week. It was reported that the usual cost quoted for out-of-agency training runs between

[1] Federal Aviation Administration. *Training*, FAA Handbook No. 3000.6A, 11 September 1969.

$300 and $450 per student week. These figures, which include cost of course development, are used as evidence that Academy training costs substantially less than out-of-agency training. Another basis used for justifying the acquisition of equipment for the Academy is to establish an in-house capability for attrition training.

In summary, there are no official criteria and standards defining the procedures for purchase and installation of equipment at the Academy for maintenance training purposes. Clearly, criteria and standards need to be developed in order to derive an objective means for weighting and evaluating the various factors which need to be taken into consideration in determining what equipment needs to be installed at the Academy. The next section discusses the function and utilization of the equipment in the training environment.

EVALUATION OF EQUIPMENT PROCUREMENT FOR ANF–CONDUCTED TRAINING COURSES

While the FAA does not have any documented policy or criteria governing the procurement of equipment for training purposes, procurement decisions have been made as evidenced by the presence of equipment at the Academy. One approach to evaluating the undefined procurement policy is to determine whether the equipment currently employed in a course is required to meet the maintenance concept validated training outcomes established for that course.

The equipment procurement decisions studied are those for equipments for which a Maintenance Concept was provided. Courses employing those equipments are the ARTS III, No. 42002, and the Diesel Engine Generator, No. 40104 and I/O Devices for Technicians, No. 43411. In view of the possibility that the equipment procurement decision process did not place paramount consideration upon whether or not the equipment was to be used in meeting training outcomes dictated by the maintenance concept, training outcomes which could not be validated against the maintenance concept were also examined.

Results

Tables 9 through 11 summarize the data. For each Training Outcome required, the tables indicate whether the outcome is valid. They also indicate whether training to meet that outcome requires the availability of the prime equipment. Each table is accompanied by explanatory notes.

Conclusions

(1) In view of the fact that the ARTS III equipment was procured much more recently than the prime equipment for the other two courses and there is a valid ARTS III training outcome requiring equipment, current policy could place considerable weight upon whether the training outcome requiring the equipment is or is not valid.

(2) Again, in respect to the ARTS III equipment procurement decision, if the primary criterion was that prime equipment can be procured only to satisfy training outcomes dictated by the maintenance concept, then current policy does not require any cost-effectiveness considerations of alternative means of meeting the training outcome. This statement is based upon the fact that the ARTS III course has only one valid training outcome, and there are possible alternatives to the prime equipment in meeting this outcome.

(3) If current policy does not require consideration of the validity of the training outcomes, it does require that the course include at least one outcome requiring the prime equipment before procurement is approved.

Table 9

Course Training Outcomes

I. ARTS III - Course No. 42002

Training Outcomes Required	Maintenance Concept Validated?		Requires Prime Equipment?	
	Yes	No	Yes	No
1. Locate and identify all subassemblies and controls.	x		x	
2. Perform all maintenance checks and adjustments.		x	x	
3. Recognize, analyze, localize, and correct all deficiencies and malfunctions.		x	x	
4. Evaluate effects of related equipment—i.e., those equipments interfacing with the ARTS III System.		x		x
5. Analyze, interpret, and modify printouts of operational, maintenance, utility, and diagnostic programs as required.		x		x
6. Understand circuit, subsystem, and overall system operation of the ARTS III equipment.		x		x
7. Generally understand the operational program with emphasis on confidence testing and use of the operational program as a maintenance tool.		x		x
8. Assume full responsibility for maintenance of the ARTS III system.		x	x	

Explanatory Notes for Table 9:

1. Yes. Of the outcomes for all three courses, only this outcome was validated by the Maintenance Concept. This outcome could require the presence of the prime equipment, but this would depend upon the size and complexity of the equipment and the proficiency expected of the trainee at time of graduation. Lower levels of proficiency can be attained through use of mock-ups and other types of graphic or pictorial training aids.
2. Yes. The prime equipment or a very high fidelity simulator would be required here.
3. Yes, partially. The equipment is required for correction of all malfunctions. However, prime equipment would not necessarily be required in developing skills in the recognition, analysis, or localization of deficiencies and malfunctions. These skills are currently being developed, in part, through use of printed media. There is some serious doubt as to whether this outcome is met, specifically in terms of the recognition of all deficiencies and malfunctions. Deficiencies are more likely to be detected rather than recognized. Graphic or pictorial aids can be used to train personnel to recognize many malfunctions.
4. No. Development of the ability to evaluate the effects of related equipment upon the ARTS III can be accomplished in the absence of the prime equipment. This could be done much in the same manner as for interfacing circuits within the ARTS III, such as, "what effect will there be on Stage B output of the input from State A is . . ."

(Continued)

Explanatory Notes for Table 9 (Cont.):

5. No. The prime objects to be manipulated here are printouts, not the equipment itself.
6. No. This type of knowledge can be developed in absence of the equipment.
7. No. Prime equipment is not required to develop a general understanding.
8. Yes. This training outcome can encompass so many different maintenance duties and tasks for which proficiency can only be developed by practice on the prime equipment. Also implied is that the trainee be able to keep the equipment totally operational without any assistance from other personnel.

Table 10

Course Training Outcomes

II. Diesel Engine Generator - Course No. 40104

Training Outcomes Required	Maintenance Concept Validated?		Requires Prime Equipment?	
	Yes	No	Yes	No
1. Locate and describe the function of control panel components.		x	x	
2. Perform a no-load and full-load test on an engine generator.		x	x	
3. Demonstrate and explain safety precautions associated with diesel engine generators.		x	x	
4. Explain the basic principles of the operation of diesel engine generators.		x		x
5. Analyze the performance of the diesel engine generator.		x	x	
6. Analyze and test fuel injector performance.		x	x	
7. Inspect, install, and time fuel injector pumps.		x	x	
8. Analyze, test, and adjust mechanical and hydraulic governors.		x	x	
9. Inspect, service, and repair the generator and exciter.		x	x	
10. Analyze, service, and adjust the voltage regulator.		x	x	
11. Analyze, adjust, and repair the associated control panel.		x	x	
12. Use wiring, schematic, and "one line" diagrams to isolate and repair defective control panel operation.		x	x	
13. Perform preventive and corrective maintenance tests, performance checks, and adjustments of the engine generator.		x	x	
14. Assume full maintenance responsibility.		x	x	

Explanatory Notes for Table 10:

1. Yes, maybe. The comment here is the same as for the ARTS III No. 1 outcome. However, only the control panel is required and not the entire equipment system.
2. Yes. An engine generator would be required, but how many different ones would depend upon the extent to which the test procedures differ from one generator to another.
3. Yes, partially. Development of the ability to explain safety precautions can be accomplished without the equipment. To demonstrate would require an opportunity to integrate knowledges on safety by practice on the equipment.
4. No. The implied knowledges and the ability to explain these knowledges can be developed in absence of any equipment.
5. Yes. The opinion here is development of an ability to analyze the performance of mechanical equipment which cannot be achieved as easily without prime equipment as development of the same ability on electronic equipment. This same type of analytical skill for electronic equipment can be developed by use of conceptual representations (schematics, circuit diagrams, etc.) of the equipment, whereas with mechanical equipment this is not entirely possible. A possible explanation could be that analysis of mechanical equipment performance depends heavily upon the availability of auditory, tactile, and olfactory cues.
6. Yes. There is the requirement for equipment here but there is the possibility that the entire diesel engine generator might not be required. This is based upon the possibility that a test stand could be obtained for the fuel injectors, permitting their performance to be analyzed and tested independently of the engine generator.
7. Yes. However, training someone to inspect a fuel injector pump can be accomplished without requiring the engine generator.
8. Yes. The same comment as "(7)" could be made in respect to the adjusting of the governors, and this would depend entirely upon whether the adjustments are made independently of the equipment on which the governor is to be installed.
9. Yes, partially. It would appear that repair of the governor or exciter is a bench type repair and could be taught as such. If this is true, the repair portion of this outcome does not require the prime equipment system.
10. Yes, Partially. Ability to analyze the voltage regulator could be developed without requiring the diesel engine generator or voltage regulator. The servicing and adjusting would require the voltage regulator and possibly the engine generator itself.
11. Yes, partially. As with the previous outcome development of the ability to analyze does not require any equipment.
12. Yes, partially. The ability to repair would require equipment but only the control panel. It is not clear what the difference is between the repair ability in the previous outcome and the repair ability here. It would also appear that the "use of wiring, schematic, and one-line diagrams" is a part of the analysis skill of the previous outcome. The ability to effectively use that type of maintenance job aid material to isolate equipment defects can be developed without the aid of the prime equipment.
13. Yes. This outcome would require the prime equipment.
14. Yes. Same as above.

Table 11

Course Training Outcomes

III. I/O Devices for Technicians - Course No. 43411

Training Outcomes Required	Maintenance Concept Validated?[a]		Requires Prime Equipment?	
	Yes	No	Yes	No
1. Understand IBM's Solid Logic Technology symbols, component layout, and packaging and documentation as used in the Flight Strip Printer Control Module.				x
2. Understand, in block diagram form, how the IOCE, PAM, FSPCU, and FSP units are interconnected.				x
3. Disassemble and reassemble parts, make mechanical adjustments, and understand operation and electrical circuitry of the 1980 Flight Strip Printer.			x	
4. Use the OLSA to check operation of the 1980 Flight Strip Printer.			x	
5. Understand the 1052 Printer-Keyboard mechanical and electrical operation.			x	
6. Disassemble and reassemble parts, understand operation, perform mechanical adjustments and electrical troubleshooting on the 029 Card Punch.			x	
7. Trace logic signals from input to output and understand logic functions of the 7289-03 Flight Strip Printer Control Module (FSPCM).				x
8. Isolate malfunctions in the 7289-03 to a single component by use of the maintenance panel, indicator panels, scope and diagnostic program.			x	
9. Understand 7289-03 power supply normal sequencing, recognize emergency and special power-off sequences, and use charts and interlock diagrams to isolate troubles.			x	
10. Locate parts and part numbers in IBM parts manuals.				x
11. Understand preventive maintenance and lubrication on the 1980 Flight Strip Printer, 1052 Printer-Keyboard, and 029 Card Punch.				x

[a]The Maintenance Concept provided was found to pertain to CDC/CUE and precluded validation of the training outcomes.

Explanatory Notes for Table 11:

1. No. No equipment would be required to achieve this outcome.
2. No. Same as "(1)."
3. Yes, partially. Disassembly and assembly activities would require equipment. An understanding of operation and circuitry can be developed without equipment.
4. Yes. Both the OLSA and Flight Strip Printer equipments would be necessary for training.
5. Yes, partially. Whether or not equipment would be required would depend upon the depth of understanding of the mechanical operation to be achieved.
6. Yes, partially. The comments under "(3)" would also apply here.
7. No. Logic signal tracing is done on paper and developing an understanding of logic functions can be accomplished without equipment.
8. Yes, not only the 7289-03 equipment is required but also a "scope."
9. Yes. The only portion of this outcome which could require equipment pertains to the ability to "recognize emergency and special power-off sequences." A mock-up or front-panel simulator could be used in lieu of the prime equipment. This, of course, would depend upon the discriminatory process in the recognition act and the sensory cues involved. Also to be considered, would be the speed and accuracy of recognition required.
10. No. Only parts manuals would be required.
11. No. The comment made on previous outcomes involving ability to understand would apply here.

EVALUATION OF UTILIZATION AND FUNCTION OF PRIME EQUIPMENT IN RESIDENT TRAINING

Objective

The second step in the overall evaluation of equipment requirements concerned evaluation of the appropriateness and role of the prime equipment in the course environment for meeting training outcomes required by the maintenance concept.

Method

Two data sources were used in this evaluation: the course control documentation and on-site observations of resident training by members of the research staff.

The evaluation was limited to the maintenance concept validated training outcome of the ARTS III course. The required outcome is that the trainee should be able to locate and identify all subassemblies and controls.

Results

(1) Course Control Documentation

Guides or outlines for all laboratory exercises were not provided. Those provided were for Data Entry and Display Subsystem laboratory exercises Numbers 1, 3, 5, 6, and 7 and the I/O Buffer Step laboratory exercise. None of these guides indicate a specific effort is to be made to achieve the identified training outcome. However, it is very apparent that the trainee, in performing the exercises as described by the guides, would learn the name and location of many controls and subassemblies found within the Data Entry and Display Subsystem.

An examination of the ARTS III Instructor's Guide indicates that during lectures the student would be repeatedly exposed to the names of system components of varying levels, such as subsystem, assemblies, and circuit, and the name of (location) the next higher level component.

(2) On-Site Observation

During the observation period, one laboratory exercise was observed. This laboratory was actually a demonstration which afforded the students no hands-on experience. During the demonstration, the instructor operated certain controls and directed the student's attention to resulting indicator lamp configurations. Although no overt attempt was made to determine that students could locate and identify subassemblies and controls, it was clear that some learning toward this end could be achieved. Thus, the content was relevant to a maintenance concept valid training outcome, although only incidentally.

Conclusion

The achievement of this training outcome currently involves some combination of lecture presentations and practice on the prime equipment. Unfortunately this conclusion is not very helpful as it is restricted to the single, identified, valid training outcome required.

FACTORS INFLUENCING EQUIPMENT PROCUREMENT DECISIONS

Objective

The objective was to consider the influence of certain factors on the decision to furnish equipment to the Academy. These factors are (a) similarities of equipment in the same family; (b) longevity of training requirement; (c) on-the-job training at site, (d) pre-production versus first production model; (e) requirement to train in advance of the field requirement for maintenance personnel; (f) the alternative to either purchase or borrow equipment from the field or production line. Again, since there are no formal and established procedures documented covering decisions to furnish equipment, the following discussion must be in terms of what was found in the informal process.

Method

Information bearing upon these factors was obtained through interviews with FAA officials, regional employees in supervisory and instructional capacity, and review of certain publications. The findings are a distillation and summary of data from these sources.

Similarities of Equipment in Same Family

As indicated, there is no formal procedure enunciated for or requirement for Academy personnel to compare new equipment with similar equipment already installed for the purpose of determining the suitability of the installed equipment as a substitute for the new equipment.

Longevity of Training Requirements

When new equipment or systems are to be installed on site, the overall training objective, with respect to the maintenance of this equipment, appears to be to schedule equipment and training in such a way that maintenance personnel having the requisite skills and knowledges will be available on site when the equipment is installed. Then, at commissioning time, personnel will be available to perform the necessary maintenance.

Once sufficient personnel have been trained to satisfy the initial training requirements, the long-term requirement for equipment is assessed in terms of the need for either backfill or attrition training. Backfill training is a special case of attrition training

resulting from the movement of personnel in one career field to another career field, and attrition training is a general case of personnel no longer being available for the maintenance of particular equipments. There does not appear to be any overall or general policy regarding when to terminate training in particular equipments at the Academy.

On-the-Job (OJT) Training at Site

A more detailed discussion of OJT at site is provided later in this section. At the present time, two forms of on-the-job training are conducted at site. One is the formal OJT embodied in the integrated programs; the other is informal OJT, which is relatively unstructured and is apparently the dominant method. As it is presently structured, OJT is predominantly utilized when additional technicians are required to ensure maintenance capability on all shifts.

Pre-Production vs. First Production Model

The pre-production model is likely to be different from the first production model. The primary advantage of using the pre-production model for training is in terms of its timeliness—that is, it is available in advance of the availability of the first production model. Consequently, training can be conducted earlier using the pre-production model than using the first production model.

Training on the pre-production model is probably more beneficial for key cadre personnel—that is, course development personnel—than for site personnel because key personnel trained on the pre-production model will probably have enough information to develop the course. They will have to modify it as a result of changes which appear in the first production model. The desirability of using the pre-production model versus using the first production model as training equipment would have be be evaluated in terms of (a) the degree of similarity between the two and (b) the purposes to which the equipment will be put in the maintenance training to be developed.

Requirement to Train in Advance of the Field Requirement for Maintenance Personnel

It is clear from the informal process reviewed that one of the key objectives is to train in advance of the field requirement for maintenance personnel—that is, the FAA does not wait until equipment has been installed at a site before attempting to train individuals to maintain it. In general, this is a desirable objective. A problem can arise, however, in situations where training is conducted and completed so far in advance of the installation of the equipment at a given site, that individuals run the risk of forgetting essential knowledges and experience degradation of skills before they can apply them. This is a matter of dovetailing personnel training schedules with installation check-out and commissioning schedules for the equipments.

Alternative to Purchase or Borrow Equipment from the Field or Production Line

It would appear that the decision to purchase the equipment for the Academy largely depends upon a judgment that a sufficiently high continuing requirement for training on the equipment will remain after initial training has been completed, and the desire to provide an in-house capability to provide this training for some time. The borrowing of equipment from the field or production line as an exclusive method appears to be used in those situations where combined OJT and directed study are used as an acceptable method for handling the attrition training phase.

CRITERIA REGARDING THE RETIRING OF ACADEMY EQUIPMENT

No formal criteria governing the retirement of Academy equipment were found. FAA Order No. AC 3000.18A,[1] Section 3, "Training Course Termination," Paragraph 47, states that the training program standards, Chapter 13, 3000.6A, require the establishment of a procedure for recommending training course termination.

Paragraph 15 of Appendix 4 (Chapter 13 of Changes 2—Handbook No. 3000.6A) is devoted to program element: Training Course Termination. The "Program Standards" of this paragraph appear to require establishment of procedures relating to training course termination.

Paragraph 49 of AC 3000.18A is entitled "Procedure." It states: "Each training branch shall annually review all courses under their administration for the purpose of recommending termination to TR-1 of courses that fall into any of the following categories:

- (a) Student participation is not representative of the intended student input as defined in the Training Plan.
- (b) Annual participation in the course is so low that the cost of revising and updating material, and instructor preparation time, cannot be economically justified.
- (c) The course duplicates training covered in other available courses.
- (d) Field requirements are questionable, i.e., the courses can no longer be classified in any of the following categories: (1) Mandatory; (2) Job Required; (3) Highly Desirable; (4) Performance Improvement; (5) Career Development."

Whenever a course falls into one of these four categories it may be recommended for termination. If that should occur, disposition of installed equipment facilitating training must be made.

Since the guidance provided within the above "Procedure" fails to prescribe how the branches shall determine that, for example, student participation is not representative of the intended student input as defined by the training plan, or what amount of course duplication is tolerable, it is concluded that the "Procedure" for Training Course Termination is lacking in detail.

When training courses are terminated there is the implication that equipments no longer required for training need to be disposed of. Yet there is no guidance as to what to do with equipments when it has been determined that the course will be terminated. However, Training Course Termination is not identical to equipment retirement. Termination of a course does not automatically and invariably require disposal of the equipment. If it is sufficiently like some other equipment, it may find use in support of laboratory exercises of another course in those aspects wherein similarity permits its use. Thus, although there is a policy for course termination, no procedures for retirement of equipment, per se, were found.

ADVANTAGES AND DISADVANTAGES OF USING OPERATING EQUIPMENT AT FIELD SITES FOR MAINTENANCE TRAINING

Operating equipment at field sites is used for maintenance training. The desirability of using the equipment for this purpose depends upon the manner in which it is used.

[1] Federal Aviation Administration. *FAA Academy Training*, FAA Order No. AC 3000.18A, 18 November 1970.

Advantages. The primary advantage to the technician in training on operating equipment is in terms of the development of performance proficiency. In the Resident Course laboratories, trainees frequently work in two- or three-man teams. There is not always sufficient time to permit each member of the team to perform all requirements of the exercise. As a result, some trainees may have to content themselves with observing a procedure rather than performing it. Consequently, the development of a full performance proficiency must await their subsequent work experience on the job.

At the operating site, trainees have the advantage of being trained by a lead technician or technician-in-depth who has had first-hand experience in dealing with the peculiarities of that particular system.

The trainee has the opportunity to observe and practice maintenance techniques and procedures found to be effective and performed by experienced maintenance personnel at the site. Because of the criticality of time pressures placed upon experienced maintenance personnel in accomplishing their work activities, the trainee gains an appreciation for the speed and accuracy requirements found to be acceptable and required in the performance of maintenance work. The trainee has the opportunity to perform scheduled routine preventive maintenance procedures to a depth and level of completion that would be infeasible in a formal resident training situation.

Disadvantages. In general, the prime disadvantage of using operating equipment for training on site is lack of availability of equipment. The prime mission of equipment installed on site is to satisfy an operational requirement. In a simplex installation when the equipment is required continuously, the only period of availability would be during normally scheduled preventive and routine maintenance operations, or when an equipment failure took the system off line. In the latter instance, because of the urgent requirement to return the system to its operational status it is extremely unlikely that experienced technicians would take the time to use the occasion for training purposes. Thus, any benefit to be derived from observing the experienced technician performing troubleshooting and repair activities by the inexperienced trainee would likely be minimal; in any event, benefit would be a direct function of intensity and acuity of the trainee's observational capability.

In duplex installations the trainee would fare somewhat better as the pressure to restore the prime equipment would not be as great since the back-up equipment would be in use. The pressures are there, nonetheless, since the chance exists that the back-up equipment could fail while the prime equipment is being repaired.

Since on-site equipment is operational equipment, the opportunity to create troubleshooting problems for the trainee to solve, although available, would not be exercised because of the fear that an inserted troubleshooting problem might cause other unknown problems to occur, and because the back-up system might be required immediately due to a failure in the prime system. Thus, practice rehearsal of troubleshooting problems on operational equipment would not be feasible.

The potential exists for an increased cost due to spares consumed in training. Interviews with personnel conducting OJT on site revealed that no records are made of such costs nor was there any recognition that such costs were incurred.

Without a carefully programmed OJT effort there would be no hope for standardization of training content even with an OJT program that was well defined. In practice, the conduct of the OJT would very likely be highly variable from one site to another and from one trainer to another at the same site.

FUNCTIONS AND LIMITATIONS OF REGIONAL EMPLOYEES USED AS ON-THE-JOB TRAINERS

Regional employees are used for training purposes in a number of different ways. When the local requirement is identified for training in theoretical or conceptual topics (e.g., mathematics), a locally conducted resident training program in such matters will be organized and conducted for those who are interested in attending. The primary motivation for doing this appears to be in terms of preparing individuals to perform satisfactorily when they arrive at the Academy.

Experienced technicians are also utilized in the conduct of on-the-job training of the informal type. In this arrangement the principal method used is to assign a trainee to a trainer who will then engage the trainee in such maintenance training activities which he judges to be beneficial.

Technicians are also utilized in the formal OJT mode. The trainee's immediate supervisor may or may not perform as the trainer. Factors which influence this are the supervisor's qualifications in the equipment for which training is to be conducted and the availability of other qualified personnel below the supervisory rank to perform the trainer function. In the formal OJT mode the trainer has certain administrative responsibilities as well, particularly in connection with the recording of training time and accomplishment of training objectives as indicated on the Training Progress Chart and the submission of these charts on a timely basis.

Although in the formal OJT mode considerable guidance is given to both the trainer and the trainee, the effectiveness of the training will to some extent be a function of the degree to which the trainer embraces not only the letter but also the spirit of the training requirements, within the limitations imposed upon him by the operational job.

Whether it be formal or informal OJT, the quality of the instruction is both a function of the trainer's ability to perform as an instructor and the time pressures imposed upon him by the requirements to maintain the equipment. With respect to the formal OJT, the ultimate objective of OJT-2 is certification of the mechanic on the equipment or system if a certification requirement exists. Since satisfactory completion of the resident training program fulfills the requirements for the knowledge portion of the certification exam, it is only the performance exam which the trainee must pass to become certified.

The structure of the OJT-2 program is such that in accomplishing it the trainee performs all of the necessary tasks that he will be expected to perform on the performance examination. The essential objective of the trainer in connection with OJT-2 is to insure that the trainee has sufficient opportunity to learn and practice those tasks required to be demonstrated in the performance examination.

OJT—ON-THE-JOB TRAINING

In order to collect data on the conduct and administration of OJT, visits were made to the following organizations: FAA Center, Leesburg, Virginia—1 September 1971; Washington National Airport—13 September 1971; Indianapolis Sectors - HUB and ARTCC—20 September 1971.

Of particular interest was the OJT conducted on behalf of integrated programs, particularly for the I/O for Technicians area, Diesel Engines area, and Communications Equipment. Some peripheral information was also collected in connection with informal OJT. Discussions were held with management personnel, first line supervisors, trainers, and trainees. All types of personnel were not uniformly available at all installations, although management personnel were always available. Sometimes supervisors who had conducted OJT programs had transferred out of the organization as did the trainees.

A general statement can be made with respect to the three organizations visited that not a great deal of activity was under way with regard to the integrated programs of interest. In fact, at Leesburg, management was unable to identify an instance where the integrated OJT program was in effect.

Sector management officials are relatively unaware of the status of trainees as they pass through OJT programs in the integrated fashion. Apparently by design, the integrated programs tend to leave sector management out of the picture. As a consequence, it was reported that virtually the only instance where management is involved is in a situation where the trainee is having trouble—that is, in situations where the trainee fails to submit assignments on time or receives failing grades on examinations, in which case the sector management is notified of the problem.

There is apparently no requirement to report hours expended in the training function, either by the trainer or by the trainee, to the sector manager. At Indianapolis, however, the reporting of hours spent by trainees was made to the sector manager's office in both the HUB and ARTCC. This was not the case at Leesburg or at Washington National. The assumption is made in Indianapolis that the trainer's time equals the trainee's time. No other formal accounting of trainer's time is made in connection with reporting trainer's time to sector management. One objective of collecting such data would be in terms of determining the costs associated with conducting the training.

The Training Progress Charts contained within the OJT packages provide space for the trainer to indicate the amount of time spent both by himself and by the trainee in accomplishing the various training objectives. These Training Progress Charts are submitted to the Academy.

One disadvantage cited for OJT is a lack of understanding of system concepts on the part of the trainee and availability of equipment for training—that is, although it's possible to train on specific equipment items, one cannot free an entire system for determining faults of a system-wide nature. In the electromechanical area, for example, the mechanics cannot switch in the diesel generators to test out the switch gear since this might cause troubles within the complex; it is not possible to insert troubles into the system for system troubleshooting. Preventive maintenance was cited as a content area particularly suited to on-the-job training.

The following comments are indicative of the experiences technicians have had with the OJT program. One individual in the diesel engine area stated that he did not take the OJT-1 based on his prior experience with diesel engines. He did take the directed study portion, however. Since there is no certification for the diesel engine area, the motivation for accomplishing OJT-2 is minimal. The respondent believed the directed study was helpful in terms of being able to master the school program.

The primary advantage of OJT was in terms of access to the equipment in contrast to the school where three or four people have to crowd around to do something. In the OJT phase the individual can work by himself under supervision.

Advantages cited for OJT were its practical aspects and the preventive maintenance routines. The principal disadvantage cited was variable quality of an instructor. Another respondent stated he performed the directed study on his own but the OJT was done both during working hours and at home. He stated that there was always somebody to talk to about the equipment and availability of personnel was no problem.

Another respondent cited familiarity with the equipment as an advantage of OJT. The disadvantage was interference with the work at hand. On the ASR-4 a respondent said that an advantage of OJT was the closeness of attention that the instructor could pay to him—that is, a one-to-one relationship. Full access to the equipment was always possible.

Although the question was posed at all organizations, uniformly the response was that there has been no evidence to suggest that there have been training-induced equipment outages, and no evidence collected to suggest that training has caused an increase in the number of spares required for maintenance of the equipment.

In general, it would appear that management personnel would like to have information reflecting the rate of progress of their trainees through the OJT integrated programs. The communication network as it is presently designed apparently does not provide them with the sufficient information.

SUMMARY OF RESULTS

The following summarizes the results.

1. Although a policy exists, there are no formal documented procedures governing the purchase and installation of equipment.
2. Equipment was found to be required by training outcomes in the following courses:
   a. Course No. 42002: 4 out of 8 training outcomes.
   b. Course No. 40104: 13 out of 14 training outcomes.
   c. Course No. 43411: 6 out of 11 training outcomes.
3. The equipment for course No. 42002 is used incidentally for the accomplishment of the maintenance concept validated training outcome.
4. No formal procedures exist for comparing similar equipments to determine whether training is needed on new equipment.
5. No formal procedures exist for determining how long a training program should persist as a function of field requirements.
6. Pre-production model equipment training is most beneficial for key personnel.
7. Personnel are trained in advance of a field requirement so that they are available on site when the equipment is installed.
8. Purchase of equipment for retention by the Academy depends on determining a long-term training need and establishment of in-house capability.
9. No formal procedures governing retirement of equipment were found.
10. Use of operating equipment at field sites:

    Advantages

    a. Greater access to equipment by trainees when available from operations than in resident training.
    b. Closer contact with trainer, generally one to one.
    c. Greater opportunity to perform preventive maintenance.

    Disadvantages

    a. Amount of time equipment is available.
    b. Troubleshooting training problems cannot be utilized.
    c. Standardization of training unlikely.
11. Functions and Limitations of Regional Employees used as On-the-Job Trainers.
    a. Functions:
       (1) Lecturers in locally conducted theory courses.
       (2) OJT trainers in informal OJT.
       (3) OJT trainers in formal (integrated) OJT programs.
    b. Limitations:
       (1) Lack of instructor expertise.
       (2) Conflict between training and operational requirement to perform maintenance.

12. On-the-Job Training

a. OJT is more apt to be informal than formal.

b. Sector management personnel are likely to be uninformed as to OJT trainee progress or OJT costs for either formal or informal modes.

c. Advantages: Preventive maintenance training, and training in local policies and procedures; close supervision and access to experienced technicians; appreciation of necessity to work under time pressures.

d. Disadvantages: Unavailability of complete system for system-wide troubleshooting practice; conflict of operational requirements with maintenance training; lack of standardization of training; variability of trainer as instructor.

Chapter 5

EXAMINATION OF TRAINING METHODS AND RECOMMENDED ALTERNATIVES (TASK D)

OBJECTIVE

The objective of this task was to examine various training methods and determine their relative effectiveness in producing required training outcomes.

METHOD

The maintenance concepts analysis data developed in Task A were searched for training outcomes that were valid. This resulted in identification of only one training outcome in the ARTS III course. The course control document was then used to determine the methods employed to achieve the outcome. The resident training method was then compared to directed study and on-the-job training methods in terms of the relative effectiveness of accomplishing (a) presentation of knowledge, (b) exercising the knowledge, and (c) practice of performance of the objective task.

It was believed, however, that it might be more beneficial to examine not only the Maintenance Concept valid training outcome but all outcomes for the 10 courses, valid or not. This permitted the evaluation of how effectively methods were being applied, apart from the problem of validity of outcomes. Accordingly, all outcomes for all courses were examined with respect to the most effective method for accomplishing them. The categories of methods considered were: resident training, directed study, on-the-job training and programed instruction.

Judgments of the relative effectiveness of the various methods were made by the research team for individual outcomes in each of the 10 courses. In each case the method was assigned a rank from one (most effective) to four (least effective). No consideration was given to the potential cost of the methods in this analysis.

RESULTS

The ranking of the effectiveness of the various training methods for each of the training outcomes in each course is shown in Table 12.

Table 12

Ranking of Training Methods for Each Training Outcome in Each Course

Course No. 42002

Upon completion of this course the trainee should be able to:	Resident Training	Directed Study	On-the-job Training	Programed Instruction
1. Locate and identify all subassemblies and controls.	1	4	2	3
2. Perform all maintenance checks and adjustments.	1	4	2	3
3. Recognize, analyze, localize, and correct all deficiencies and malfunctions.	1	4	2	3
4. Evaluate effects of related equipment, i.e., those equipments interfacing with the ARTS III system.	1	4	2	3
5. Analyze, interpret, and modify printouts of operational, maintenance, utility, and diagnostic programs as required.	1	3	4	2
6. Understand circuit, subsystem, and overall system operation of the ARTS III equipment.	2	3	4	1
7. Generally understand the operational program with emphasis on confidence testing and use of the operational program as a maintenance tool.	1	3	4	2
8. Assume full responsibility for maintenance of the ARTS III system.	2	4	1	3

Course No. 40318

Upon completion of this course, the trainee should be able to:	Resident Training	Directed Study	On-the-job Training	Programed Instruction
1. Install system units, make proper wiring inter-connections, and insure correct coaxial cable termination.	1	3	2	4
2. Completely align all parts of the system for optimum performance	1	4	2	3
3. Recognize and analyze performance deficiencies to isolate the unit or units creating the problem.	1	4	2	3
4. Correct deficiencies by adjustment or alignment of any unit using approved procedures.	1	4	2	3

(Continued)

Course No. 40318 *(Continued)*

	Resident Training	Directed Study	On-the-job Training	Programed Instruction
5. Isolate circuit faults to individual components.	1	4	2	3
6. Repair circuit malfunctions or faults in any unit of the system.	1	4	2	3
7. Make changes in system patching and connections to meet all requirements of reconfiguration.	1	4	2	3
8. Use general and special purpose test equipment to analyze system performance and to isolate faults. Check calibration and determine the accuracy of all test equipment.	1	4	2	3
9. Train operations personnel in the correct operational use of controls that affect system performance.	4	2	1	3
10. Conduct brief training sessions for other maintenance personnel.	4	2	1	3

Course No. 40104

Upon completion of this course, the trainee should be able to:

	Resident Training	Directed Study	On-the-job Training	Programed Instruction
1. Locate and describe the function of control panel components.	1	4	2	3
2. Perform a no-load and full-load test on an engine generator.	1	4	2	3
3. Demonstrate and explain safety precautions associated with diesel engine generators.	1	4	2	3
4. Explain the basic principles of the operation of diesel engine generators.	3	2	4	1
5. Analyze the performance of the diesel engine generator.	1	4	2	3
6. Analyze and test fuel injector performance.	1	4	2	3
7. Inspect, install, and time fuel injector pumps.	1	4	2	3
8. Analyze, test, and adjust mechanical and hydraulic governors.	1	4	2	3
9. Inspect, service, and repair the generator and exciter.	1	4	2	3
10. Analyze, service, and adjust the voltage regulator.	1	4	2	3
11. Analyze, adjust, and repair the associated control panel.	1	4	2	3

(Continued)

Course No. 40104 *(Continued)*

	Resident Training	Directed Study	On-the-job Training	Programed Instruction
12. Use wiring, schematic, and "one-line" diagrams to isolate and repair defective control panel operation.	1	4	2	3
13. Perform preventive and corrective maintenance tests, performance checks, and adjustments of the engine generator.	1	4	2	3
14. Assume full maintenance responsibility.	2	4	1	3

Course No. 40001

Upon completion of this course, the trainee should be able to:

1. Analyze and repair electronic communications equipment by use of schematic diagrams and cause-and-effect reasoning	1	4	2	3
2. Evaluate telephone control and communications lines operation by performing line runs.	1	4	2	3
3. Inspect, clean, adjust, and repair telephone type relays.	1	4	2	3
4. Utilize standard test equipment to measure performance and speed servicing of communications equipment.	1	4	2	3
5. Analyze, service, and check performance of FAA communications receivers.	1	4	2	3
6. Analyze, tune, and load FAA Communications type transmitters.	1	4	2	3
7. Understand the theory of operation of communications equipment.	3	2	4	1

Course No. 43413

Upon completion of this course, the trainee should be able to:

1. Operate the IBM-9020 System both from the Element Maintenance Panels and from the System Console, configure a system and make it ready for operation, load a source program to obtain listings, and load an object program for execution.	1	4	2	3
2. Evaluate the control paths and data paths throughout the system.	1	4	2	3

(Continued)

Course No. 43413 *(Continued)*

	Resident Training	Directed Study	On-the-job Training	Programed Instruction
3. Trace the operation of Read Only Storage (ROS) and in the CE and IOCE, including the ROS addressing scheme and control word generation and decoding.	2	4	3	1
4. Trace any instruction execution through the functional units of the CE by use of CAS (micro-program documentation), data flow diagrams, and automated logic diagrams.	2	4	3	1
5. Trace the operation and timing of Local Store, MACH store, Main Store, and Storage Protect through both fetch and store operations.	2	4	3	1
6. Recognize and correct the conditions causing parity errors by a knowledge of the methods used for parity generation and checking within the system.	1	4	2	3
7. Trace multiplexor and selector channel operations through both micro-program and hardware sequences.	2	4	3	1
8. Trace operation of the Peripheral Adapter Module (PAM) through addressing, priority, configuration, and interface circuits.	2	4	3	1
9. Trace the operation of the control units which interconnect the system oriented I/O devices to the IOCE channels.	2	4	3	1
10. Repair and perform mechanical adjustments on all system-oriented I/O devices except the IBM-1052 Printer-Keyboard.	1	4	2	3
11. Trace any of the power supply circuitry from the associated regulator through the frames to the distribution points on the gates, and trace the operation of the regulators in the Power Distribution Unit and the power sequences in all elements.	2	4	3	1
12. Perform the appropriate electrical adjustments required for proper element timing and/or operation.	1	4	2	3
13. Use Maintenance Diagnostic Programs, read and interpret the listings of a diagnostic section, interpret error printouts, and use the interpret Fault Locating Tests.	1	4	2	3
14. Use special test equipment and interpret indications therefrom.	1	4	2	3
15. Evaluate and troubleshoot the IBM-9020 as a complete system or evaluate and troubleshoot an individual element.	1	4	2	3

(Continued)

Course No. 43413 *(Continued)*

	Resident Training	Directed Study	On-the-job Training	Programed Instruction
16. Write, assemble, and debug programs in Basic Assembly Language and patch and edit the Maintenance Diagnostic programs.	1	4	2	3
17. Demonstrate a knowledge of Engineering Change Procedure and Criteria for evaluating Engineering Change Performance.	3	2	4	1
18. Perform and evaluate wire wrap and delete operations on the IBM-9020 system.	1	4	2	3

Course No. 43411

Upon completion of this program, the trainee should be able to:

	Resident Training	Directed Study	On-the-job Training	Programed Instruction
1. Understand IBM's Solid Logic Technology symbols, component layout, and packaging and documentation as used in the Flight Strip Printer Control Module.	3	2	4	1
2. Understand, in block diagram form, how the IOCE, PAM, FSPCU, and FSP units are interconnected.	3	2	4	1
3. Disassemble and reassemble parts, make mechanical adjustments, and understand operation and electrical circuitry of the 1980 Flight Strip Printer.	1	4	2	3
4. Use the OLSA to check operation of the 1980 Flight Strip Printer.	1	4	2	3
5. Understand the 1052 Printer-Keyboard mechanical and electrical operation.	3	2	4	1
6. Disassemble and reassemble parts, understand operation, perform mechanical adjustments and electrical trouble shooting on the 029 Card Punch.	1	4	2	3
7. Trace logic signals from input to output and understand logic functions of the 7289-03 Flight Strip Printer Control Module (FSPCM).	2	4	3	1
8. Isolate malfunctions in the 7289-03 to a single component by use of the maintenance panel, indicator panels, scope and diagnostic program.	1	4	2	3
9. Understand 7289-03 power supply normal sequencing, recognize emergency and special power-off sequences, and use charts and interlock diagrams to isolate troubles.	3	2	4	1

(Continued)

Course No. 43411 *(Continued)*

	Resident Training	Directed Study	On-the-job Training	Programed Instruction
10. Locate parts and part numbers in IBM parts manuals.	3	2	4	1
11. Understand preventive maintenance and lubrication on the 1980 Flight Strip Printer, 1052 Printer-Keyboard, and 029 Card Punch.	1	4	2	3

Course No. 40216

Upon completion of this program, the trainee should be able to:

	Resident Training	Directed Study	On-the-job Training	Programed Instruction
1. Locate and identify all subassemblies and controls.	1	4	2	3
2. Perform all maintenance checks and adjustments.	1	4	2	3
3. Recognize, analyze, localize, and correct all deficiencies and malfunctions.	1	4	2	3
4. Operate all related test equipment and tools.	1	4	2	3
5. Evaluate the effects of related equipment.	1	4	2	3
6. Analyze the operation and functions.	1	4	2	3
7. Assume full maintenance responsibility.	2	4	1	3

Course No. 40115

Upon completion of this course, the trainee should be able to:

	Resident Training	Directed Study	On-the-job Training	Programed Instruction
1. Understand the theory of operation of diodes, Zener diodes, transistors, unijunction transistor, silicon-controlled rectifiers, and silicon control switches.	3	2	4	1
2. Be familiar with typical electro-mechanical type circuits using the above-mentioned devices.	3	2	4	1
3. Recognize malfunctions in typical circuits, analyze and localize the malfunctions, and replace the defective solid-state devices in the circuit without damaging the new device or circuit.	1	4	2	3
4. Operate all related test equipment and tools.	1	4	2	3
5. Accept theory training on any electro-mechanical equipment containing solid-state devices.	3	2	4	1

(Continued)

Course No. 40200

Upon completion of this course, the trainee should be able to:	Resident Training	Directed Study	On-the-job Training	Programed Instruction
1. Identify and explain the operation of the RF and magnetic devices used in the RTN-2 TACAN equipment.	3	2	4	1
2. Recognize and evaluate the waveshaping amplification and pulse circuitry in the TACAN equipment.	1	4	3	2

Course No. 40210

Upon completion of this course, the trainee should be able to:	Resident Training	Directed Study	On-the-job Training	Programed Instruction
1. Explain the complete theory of operation.	3	2	4	1
2. Evaluate the operation and performance of the equipment.	1	4	2	3
3. Diagnose and correct equipment malfunctions.	1	4	2	3
4. Perform all maintenance checks and adjustments in accordance with current operating standards.	1	4	2	3
5. Perform a full system alignment.	1	4	2	3
6. Properly use all facility test equipment.	1	4	2	3

DISCUSSION

The following discussion explains the ranking and provides the rationale for the choices made.

Course No. 42002. The most effective method of obtaining the training outcomes for this course is by resident instruction. This is due, principally, to the course's heavy emphasis on hardware matters. While it is true that when equipment is on site OJT could be an alternative, it is judged not to be so effective since resident training provides opportunity for greater control over the learning process and does not interfere with an operational requirement. Programed instruction was judged to be a more effective method of teaching circuit understanding, although resident instruction was next choice. OJT was judged the most effective method of ensuring that the trainee would be able to "Assume full responsibility for maintenance of the ARTS III System," since it is on site that the technician must work and within the specific constraints that exist at his own installation.

Course No. 40318. Resident instruction was judged to be the most effective method in accomplishing the training outcomes for this course, for the same reasons given for Course No. 42002. OJT was selected for the most effective method with respect to training operations personnel, and maintenance personnel. This is mainly because local conditions on site would have an influence on what and how training would be conducted.

Course No. 40104. Because of heavy equipment involvement, resident training was selected as the most effective method for accomplishing the training outcomes for this course. Programed instruction was selected as the best method to teach the basic principles of diesel engine generators, with directed study next best. OJT was selected as the most effective method to ensure that the technician would be able to assume full maintenance responsibility, for the reasons cited for Course No. 42002.

Course No. 40001. Resident training was selected as the most effective means for accomplishing the training outcomes for this course because of its equipment orientation. But programed instruction was selected as the most effective method to teach the theory of operation of communications equipment.

Course No. 43413. Resident training was judged to be the most or next most effective method for accomplishing 17 of the 18 training outcomes for this course. Programed instruction was selected as the most effective method to use in 8 of the 18 training outcomes. Of those eight, seven involved tracing operations, the other involved demonstrating a knowledge of Engineering Change procedures.

Course No. 43411. Although resident training was selected for only 5 of 11 training outcomes, it was judged the most effective method because of the need for controlled access to hardware. Programed instruction was selected for the six training outcomes which were clearly cognitive in nature, requiring understanding of symbology, unit interconnection, and so forth. Directed study was considered to be the next most effective method on those six.

Course No. 40216. Resident training was obviously the most effective method because of the clear-cut involvement with hardware and the greater control over training that the resident instruction method affords in comparison to OJT. However, OJT was selected as the most effective in terms of developing the ability to "Assume full maintenance responsibility" because of the specific requirements that an individual's work imposes upon him.

Course No. 40115. Programed instruction was judged to be the most effective method of accomplishing three out of five training outcomes for this course. Resident training was selected as the most effective for the remaining two because of their hardware orientation. This student-centered training program already employs a form of programed instruction, and might well be administered through the mail were it not for the requirement for laboratory exercises. For this reason, the present method is concluded to be the most effective. Additional comments on the possibilities for altering this course are included in Volume II.

Course No. 40200. Programed instruction was judged as the most effective method to use in accomplishing the first of the two training outcomes. Resident training was selected for the second, largely because of the requirement for laboratory exercises. However, because of the need for laboratory exercises tied to lecture presentations, the infeasibility of sending the laboratories to the field and the effort to program the lecture materials, resident instruction is judged to be the most practical and effective method.

Course No. 40210. Resident training was judged the most effective method for accomplishing 5 of the 6 training outcomes for the course. Programed instruction was judged as the best method by which to teach theory of operation.

SUMMARY

Resident instruction was selected as the most effective means to accomplish the training outcomes in 8 of the 10 courses. In the two principles courses, programed instruction was ranked highest. The I/O for technicians course No. 43411 was split almost evenly between resident and programed instruction.

What emerges from this analysis is that some kinds of training can be more effectively accomplished through programed instruction even in courses that are predominantly hardware oriented—specifically, theory of operation. The case for more programed instruction in principles courses is even clearer since the content is *not likely* to change as in a course on specific hardware items that undergo modification and improvements over time. However, these considerations must be reviewed in the light of potential development costs. This consideration is reserved for later discussion.

EXAMINATION OF EFFECTIVENESS OF ALTERNATIVE TRAINING METHODS

MAINTENANCE CONCEPT VALID TRAINING OUTCOME

The analysis of the validity of 10 ANF training courses resulted in the finding that only the ARTS III course had a valid training outcome. This training outcome, "locate and identify all subassemblies and controls," was used as the basis for the original analysis. Analysis of this single case is insufficient. Therefore, the analysis described in the preceding section was performed. The following material is included for completeness only.

Study of the control documentation for the ARTS III course indicated that some combination of two basic methods of training (i.e., classroom lecture and laboratory exercise) were utilized to achieve the training outcome mentioned. The alternative categories of instruction compared to resident training were directed study and on-the-job training. The effectiveness of these categories was examined in terms of the extent to which they could be expected to accomplish the following three functions: (a) present the required knowledge; (b) exercise the knowledge; (c) practice the student in performance of the objective task.[1]

COMPARISON OF ALTERNATIVE CATEGORIES OF INSTRUCTION

1. Resident training versus directed study.

FAA Handbook 3000.6A, *Training*, describes directed study as "a training program conducted primarily by correspondence." Resident training is the more effective means for achieving the training outcome for the following reasons:

a. Directed study is a less effective means for presenting information than the lecture because it does not provide any means for the learner to react or respond to that information which is being presented. Furthermore, it lacks the means for instantaneous detection of whether the student understands the information he is receiving, and the means for immediate reinforcement of the knowledges to be developed. The lecture method would not have this weakness with a competent instructor present.

[1] R.G. Smith, Jr. *The Designs of Instructional Systems*, HumRRO Technical Report 66-18, November 1966.

This conclusion is based upon the analyst's perception of directed study as it is currently conducted. The differences noted between the two categories of training could become insignificant if the directed study involved use of self-instructional programmed texts which incorporated mechanisms for student response and reinforcement. This observation is limited to the presentation of information necessary for the development of the knowledge components of the task "locate and identify all subassemblies and controls."

b. Directed study does not provide as effective means as resident training for exercising the knowledges being acquired. The only identifiable mechanism for this in directed study appears to be the examinations. Resident training is considered to be more effective simply because it has the means for determining in a shorter period of time whether the student "exercised" the knowledge correctly and the means providing reinforcement in a more timely manner. This is based upon the understanding that the supervisor does not score, evaluate, or discuss the results of the examination with the trainee.

c. Directed study does not have any means for practice by the student in the performance of the total task, for purposes here, the training outcome. The demonstration and practical exercise methods found in resident training can effectively accomplish that function.

2. On-the-job training versus directed study.

FAA Handbook 3000.6A provides the following definition of OJT: "On-the-job training is planned training conducted at the work site by the supervisor or his designee as an integrated part of an employee's normal work assignment. This type of training provides direct experience in the work environment in which the employee is performing, or will be performing his job."

On-the-job training is considered to be more effective than directed study in achieving the required training outcome because it can provide the means for practice of performance of the objective task. Directed study programs are perceived as containing neither direction nor guidance to the student for the practice of performance of any psychomotor activity, such as locate and identify equipment components and controls. OJT also requires the presence of a trainer. This individual could be equally as effective as an instructor in resident training in accomplishing the other two functions.

3. On-the-job training versus resident training.

Compared on the basis of the previously identified training outcome, there is some evidence to support OJT as the more effective category of training. This difference would result from the more favorable student/trainer ratio expected in OJT as opposed to less favorable and higher student/instructor ratio found in resident training. In the function of presenting information or knowledge, there is no reason to suspect OJT would be any more effective than resident training.

The difference in effectiveness would occur in the remaining functions of practicing knowledge and practicing performance. The trainer in the OJT system would be more effective in monitoring, guiding, and reinforcing correct responses from the student during his practice solely because he would be training fewer students at a time than the typical resident instructor.

There is another aspect of OJT which could render it more effective than resident training. OJT effectiveness, since it occurs in the real job environment, should enhance the transfer of training. Resident training, on the other hand, is to some degree a simulation of the real job environment. Equipment layout and configurations within the classrooms or laboratories are not necessarily identical to those found in the field. If those differences were great enough, training received during a resident course on the

location of subassemblies and controls could interfere with learning of the location of the same controls and assemblies on the same equipment once the resident graduate is on the job.

The lower student/trainer ratio which typifies OJT also means the trainer should have less difficulty in adjusting his instruction to accommodate individual differences in his trainee population.

RELATIVE COST OF ALTERNATIVE METHODS OF TRAINING

OBJECTIVE

The objective of this part of the research was to obtain an estimate of relative costs of utilizing alternative training methods.

METHOD

Training plans were identified as one source of data on the cost to develop and conduct various categories of instruction. The categories were resident training, OJT, and directed study. Cost data from a number of different training plans were studied and examined. These data could not be used as the basis for deriving cost because the methods were directed toward the production of different products. In order for the comparison to be meaningful, the costs associated with the methods compared must be relative to the production of the same product of the same quality. The differences in the scope and objectives of training under the directed study, OJT, and resident training methods were too great and made it impractical to use training plan cost data as the basis for deriving relative cost.

The approach used in determining relative cost was to examine the different types and sources of cost for the alternative methods and make logical inferences on the overall and total method costs. Costs were examined on the basis that the methods compared were used to produce the same products of comparable quality. This product was an individual who, when supported by pertinent instruction manuals, is able to locate and identify all subassemblies and front panel and console controls in the ARTS III system in a typical field installation within 15 minutes and without error.[1]

DISCUSSION OF COST OF ALTERNATIVE TRAINING METHODS

1. Directed study versus resident training cost.
   The resident training method would incur lesser costs for the following reasons:
   a. Development Costs.
      There should not be any significant differences in costs for development of materials for two courses where one employs the printed word and graphics as the basic media and the other course relies on an instructor.
   b. Conduct of Instruction Cost.
      Resident training would involve greater cost than directed study. This difference would result from the fact that directed study does not require an instructor. Both methods would involve the use of clerical personnel in

[1] A hypothetical performance standard.

course administration. Directed study would incur costs for the transmittal of study materials and examinations. Both methods would involve costs for the physical space used for the conduct of training. Resident training would involve a greater cost here, but the absolute difference would depend upon a utilization factor, that is, the number of student hours of instruction conducted per the same time base used in expressing directed study training facility cost. In addition, a cost for student travel and per diem would arise in resident training, but not in directed study.

Although the conduct of directed study does not require an instructor, it does require someone to administer and supervise the examinations. The salary of this individual would offset some of the costs associated with instructor salary. In view of the fact that a directed study course involves conduct of instruction for only one student at a time, the costs of conducting instruction by means of resident training should be expressed in terms of per student instructional hour. This assumes that an hour is the smallest unit of instruction found in either method. When this is done, it becomes apparent that class size is a very important factor in determining the cost to provide instruction to one student for one hour. Depending upon class size and in terms of salary costs, it is possible to conceive instances where the salary costs associated with the administration of examinations would be less in resident training than directed study by a factor of 10 or 15.

The order of the magnitude of difference in the costs to be expected from conducting training under these two methods is not capable of accurate estimation. The difficulty arises from the view that the directed study method would require more hours of instruction to produce the specified product than would resident training methods. This additional time would increase the costs of directed study by some unknown degree.

c. Training Equipment and Aids Costs.

The category of costs resulting from the use of prime equipment for training purposes involving any method of instruction is a most difficult one. There are numerous different rationales offered as to why the use of prime equipment in resident training should not constitute a cost factor. However HumRRO's view is that the use of prime equipment for training purposes in the field or in resident training represents a cost source. When equipment is purchased to fulfill an operational mission, the utilization of that equipment for any other mission or purpose has to some extent (a) reduced the capability to meet mission requirements, and (b) decreased the period of equipment utilization which otherwise would have been expected for solely the operational mission.

Adherence to a rather rigid definition of directed study precludes the use of operational equipment in the field for training purposes.

POSSIBLE MEANS FOR IMPROVING THE COST AND EFFECTIVENESS OF VARIOUS TRAINING METHODS

OBJECTIVE

The objective was to identify possibilities for improving techniques to alter costs and effectiveness of individual methods in light of modern instructional technology. (Since

the possibilities identified take the form of recommendations, this material and its related discussion are contained in Volume II of the report.)

PRACTICABILITY OF USING COMMERCIAL SOURCES OF TRAINING

OBJECTIVE

To examine the practicability of using commercial sources in order to reduce training costs in alternative methods.

The relative cost and effectiveness of out-of-agency training was examined for comparable courses offered at the Academy. The scope of this objective was restricted to the 10 ANF training courses selected for detailed analysis.

METHOD

Requests were made to the Air Navigation Facilities Training Branch, FAA Academy, for the following two sets of data on the 10 courses: (a) costs for ANF to conduct training, and (b) identification of commercial organizations which offer comparable courses, and the cost of training for each course. These and other training cost data provided by ANF were used as the basis for the examination.

RESULTS

Of the 10 courses, a commercial source of training was identified for only the ARTS III. The cost of this contractor-conducted training was $215.00 per student week for the 17-week course. Reimbursable costs for ANF conducted ARTS III (Course No. 42002) training was not available at time of the request.[1] However, a training plan for ARTS III, dated June 1971, indicates the direct cost for ANF to conduct 18 weeks of ARTS III training for a 16-student class is $18,701. Expressed on a per student week basis, the cost would be $64.93.

In addition to the ARTS III, cost data on ANF[2] and out-of-agency contractor[3] conducted courses on the ASR-7 and Solid State Video Mapper are shown in Table 13. Costs are shown on per student week basis.

There was no evidence that the out-of-agency training in these courses was either less effective or more effective than that found in the ANF-conducted courses. Due to the meagerness of the data on costs of out-of-agency training comparable to that of the 10 ANF training courses, any conclusion drawn must be guarded. Even the extension of the scope of the examination to include courses outside the original 10 ANF courses selected did not result in a significantly larger data base. However, the evidence available strongly suggests costs of ANF-conducted training would be less than that for comparable training available from commercial sources, and the use of commercial training sources as an alternative to ANF training would not be a consistent means for reducing training costs.

[1] See Table B-1.
[2] See Memoranda of Telephone Calls, Appendix B.
[3] See Table B-2.

Table 13

Cost Data on ANF and Out-of-Agency Conducted Courses[a]

Course	ANF Conducted		Out-of-Agency Conducted	
	Cost	Course Length	Cost	Course Length
ARTS III	$64.93	18 weeks	$215.00	17 weeks
ASR-7	134.68[b]	5 weeks	705.55[c]	3 weeks
Solid State Video Mapper	83.21	2 weeks	333.33[c]	2 weeks

[a]Costs are shown on a per student week basis.

[b]The training was conducted by ANF personnel at a Dallas, Texas facility, and includes expenses for the rental of classroom and office space as well as per diem and travel costs of instructor personnel. These cost factors are not included in ANF training cost for the other two courses.

[c]The data are based on training costs for FY 71.

TRAINING COURSE DEVELOPMENT COSTS

OBJECTIVE

The objective of this research was to (a) examine the practicability of using various combinations of FAA and contractor resources to develop and administer training courses; and (b) to compare the costs of contractor-conducted classes for instructors to Academy-conducted courses utilizing contractor-supplied technical information only.

The scope of this task was restricted to the analysis of FAA-furnished costs figures for courses presently taught at the Academy and data furnished to FAA by contractors.

METHOD

Two different parameters of training course development costs were examined; (a) costs to conduct training for instructors, and (b) costs of developing training courses and course materials. Consideration was given to the effect of making changes in the present system by use of contractor-furnished data and contractor-conducted instructor training.

Cost data provided by the FAA on contractor-conducted and ANF-conducted instructor training for courses presently taught at the Academy formed the basis of the examination of costs to conduct instructor training.

FAA furnished information pertaining to instances of training courses and their materials being developed but never conducted by a contractor for implementation at the Academy was used in the examination of the course development cost parameter for contractor furnished training courses and materials.

RESULTS:

Costs to Conduct Instructor Training

The cost of contractor-conducted training for instructors or other key cadre personnel as part of the training course development process was identified as being the same as for maintenance personnel from the field. The cost of ANF instructors attending ANF-conducted training courses was also identified as being the same as for other FAA personnel with the exception that travel and per diem costs would not be incurred for the instructor personnel.

The average cost for a contractor to conduct training on a one instructor for one week basis would be $417.96. The average cost for comparable ANF-conducted training would be $60.60. On an individual course basis, ANF training costs are also less than the contractor's for all three courses. Based upon the limited amount of cost data available for this comparison, caution should be exercised in drawing any conclusions. The data, as they are, do not provide any support for recommending a change in the present system toward more extensive use of contractor-conducted training for instructors as a means for reducing course development costs.

RESULTS

Contractor Furnished Training Courses and Materials

The method of analysis could not be used because there was not a known instance of an ANF-conducted course which was solely developed by a contractor.[1]

Had these data been available, a similar effort was planned for the identification of courses developed in their entirety by ANF without contractor-conducted training for instructors or the use of materials developed by a contractor for conducting training. The next step was to identify the prime cost factors in course development, select courses on basis of these cost factors and make relative comparisons.

ALTERNATE METHOD

Another tactic was used to examine course development costs. Training plans for two of the more recent equipment training courses were examined for course development cost data. The training plans were for the ARTS III for Technicians course and the Wilcox Mark I ILS course. The training plan for the Mark I ILS course did not provide development cost data on out-of-agency contractor conducted training.

Although the ARTS III training plan provided course development cost data both for out-of-agency conducted training and ANF resident training, these data had to be rejected as a basis for deriving relative costs because the ANF course development costs were based upon the use of training materials developed by the contractor. A second reason was due to a discrepancy in out-of-agency course development costs ($96,247) as identified in the ARTS III training plan and course preparation cost ($76,247) provided as part of the FY-71 out-of-agency training cost data.[2]

Due to the absence of appropriate data, it is not possible to derive relative costs for development of training courses, or to suggest changes to the present training system which would prove to be cost-effective.

[1] See Memoranda of Telephone Calls, Appendix B.
[2] See Out-of-Agency Training Cost Sheet, Appendix B, Table B-2.

If ANF and contractor training course development costs are to be clearly and cleanly contrasted, it would appear that certain cost data would have to be developed. This would include data on the cost of ANF course development efforts which would not involve utilization or capitalization of earlier efforts by a contractor on the same course. If the course development would capitalize upon or use contractor developed training materials, the cost for the contractor's course development effort or technical data should be identified separately and considered as the "base" cost for the ANF course development effort. In those instances where technical data required for ANF course development would be transmitted and acquired by means of sending instructors to contractor-conducted training courses, this cost should also be identified separately and classified as part of the "base" cost.

The second set of data to be developed would be on the cost for a contractor to only develop the training course and for the course to be immediately implementable by ANF. Cost data should also be developed separately for possible alternative means for acquiring that contractor-developed technical data required for an ANF course development effort. A direct transmittal of technical data by the contractor should be considered as an alternative to (a) sending instructors to the contractor's plant or conducted training courses, and (b) in addition, the provisioning of course materials for the conductor used in conducting his training.

From a systems viewpoint, these training course development costs should reflect all development costs expected to be incurred in meeting the total training requirement. Total, in this instance, is to mean both initial and attrition training requirements.

APPENDICES

Appendix A

COURSE INSTRUCTION OBSERVATIONS

INSTRUCTION OBSERVATION DATA
Course No. 40001

Course # 40001 Short Title CE

Date/Time of Observation 16 Aug 71 0900 Duration 2 hr Type Lec

Lesson Plan # or other content identifier 33-1, 33-2, 34-1

Previous No. of meetings of this section 133

No. of Assistants 0

No. of Students 12

1. Relevant Training Outcomes

   Understand the theory of operation of communications equipment

   Comments

   Not Job Analysis document valid.

2. Objectives of Lesson/Lab

   Determine relationship of tuned circuit Q, coupling, bandwidth.
   Evaluate band pass filter and predict selectivity expected from each type.
   Identify types of receiver noise and specify corrective action.
   Identify types of interference and specify corrective action.

   Comments

   This is a six-hour lesson. Portion covered included noise and interference.

3. Instructor Guides

   Exists and states student outcomes

   Comments

   Viewgraphs called for were not identified.

4. Student Guides/Workbooks

   Available, in use, applicable.

   Comments

5. Instructors

   No attempt to determine if student outcomes had been achieved.

   Comments

Appendix A

COURSE INSTRUCTION OBSERVATIONS

INSTRUCTION OBSERVATION DATA
Course No. 40001

Course # 40001 Short Title CE

Date/Time of Observation 16 Aug 71 0900 Duration 2 hr Type Lec

Lesson Plan # or other content identifier 33-1, 33-2, 34-1

Previous No. of meetings of this section 133

No. of Assistants 0

No. of Students 12

1. Relevant Training Outcomes

   Understand the theory of operation of communications equipment

   Comments

   Not Job Analysis document valid.

2. Objectives of Lesson/Lab

   Determine relationship of tuned circuit Q, coupling, bandwidth.
   Evaluate band pass filter and predict selectivity expected from each type.
   Identify types of receiver noise and specify corrective action.
   Identify types of interference and specify corrective action.

   Comments

   This is a six-hour lesson. Portion covered included noise and interference.

3. Instructor Guides

   Exists and states student outcomes

   Comments

   Viewgraphs called for were not identified.

4. Student Guides/Workbooks

   Available, in use, applicable.

   Comments

5. Instructors

   No attempt to determine if student outcomes had been achieved.

   Comments

6. Laboratories

Comments

Not applicable

7. Overall Comments and Suggestions for Improvement

A tape recording might be made of different types of noise and played in class. The key element is ability to recognize types of noise and knowledge of what to do to eliminate it.

Course # 40001

Short Title CE

Date/Time of Observation 16 Aug 71 1130

Duration 2 hr Type Lab

Lesson Plan # or other content identifier RV 5, RV 8 Tunable Receiver

Previous No. of meetings of this section 134

No. of Assistants 1

No. of Students 13

1. Relevant Training Outcomes

Analyze, service, and check performance of FAA communications receivers.

Comments

Job Analysis document valid

2. Objectives of Lesson/Lab

Perform measurements on tunable receivers.

Unit student outcomes

1. Utilize a tunable receiver as a standby for a fixed tuned VHF receiver when the latter must be removed from service.
2. Measure the performance of commonly used tunable VHF receivers.

Comments

This was the subject of the lab exercise

3. Instructor Guides

Available, but lab exercise sheets provide instructions to students.

Comments

4. Student Guides/Workbooks

Lab exercise sheets guide students' performance.

Comments

5. Instructors

Comments

Instructor generally waits to be called before interacting with students. Sets up equipment prior to start of exercise. No reference made to expected student outcomes.

6. Laboratories

Comments

(see above)

7. Overall Comments and Suggestions for Improvement

Closer interaction with students required with assessment of achievement of student outcomes.

Course # 40001 Short Title CE

Date/Time of Observation 19 Aug 71 0900 Duration 2 hr Type Lecture

Lesson Plan # or other content identifier 17-2A

Previous No. of meetings of this section 64

No. of Assistants 0

No. of Students 13

1. Relevant training outcomes

Comments

Analyze and repair electronic communications equipment by use of schematic diagrams and cause-and-effect reasoning.

(Analysis, yes, repair no.) Not Job Analysis or maintenance concept valid.

2. Objectives of Lesson/Lab

Comments

Student able to:

1. Analyze circuitry of the TV-6 transmitter and explain theory of operation of the various stages and controls;
2. Explain how to adjust each stage for proper operation;
3. Explain the function of the various switch operations;
4. Explain the metering function circuitry and how to evaluate the readings;

(Taken from L.P.)

2. Objectives of Lesson/Lab (Continued)

   5. Explain the function and operation of the blower air switch and air filter;
   6. List preventive maintenance steps and procedures.

3. Instructor Guides — Comments

   Instructor speaks from personal notes. Guide available. Unless student outcomes are in notes, instructor does not cite them.

4. Student Guides/Workbooks — Comments

   Available, in use, applicable.

5. Instructors — Comments

   Did not cite student outcomes. Stayed pretty much with lesson plan. Questioned students by name (practically only instance of such observed) No attempt made to actually determine if student outcomes had been achieved (through demonstration).

6. Laboratories — Comments

   (Not applicable)

7. Overall comments and suggestions for improvement

   If student outcomes are important, instructor should attempt to determine if they have been achieved through requiring students to demonstrate their knowledge.

Course # 40001 Short Title CE

Date/Time of Observation 19 Aug 71 1130 Duration 2 hr Type Lab

Lesson Plan # or other content identifier IV-3, IV-6, TVQ, Transmission line

Previous No. of meetings of this section 65

No. of Assistants 1

No. of Students 12

1. Relevant Training Outcomes — Comments

    Analyze, tune, and load FAA communications type transmitters

    Comments: Job Analysis document valid

2. Objectives of Lesson/Lab — Comments

    1. Locate all controls & explain the mechanical layout of the TV-6 transmitter.
    2. Tune and adjust the radio frequency, audio frequency, and controls of the TV-6 transmitter. Evaluate the meter readings & determine that they fall within specific tolerances.

    Comments: (Taken from TV-6 instructions)

3. Instructor Guides — Comments

    Availablc, but lab exercise sheets provide guidance on what students need do.

4. Student Guides/Workbooks — Comments

    Lab exercise guide gives instructions on what to do and what measurements to take.

5. Instructors — Comments

    Good lab briefing, but omitted statement of student objectives.

6. Laboratories — Comments

    Students work on a variety of experiments on different equipment (lab guides available for each) because not enough equipment available for them to work on same type simultaneously. TV-6 actually used in field (RCAG), purpose of lab appropriate.

7. Overall Comments and Suggestions for Improvement

Possibility exists for instructor to use schematic diagrams of other transmitters to give instruction on where to make similar measurements. Students must determine these points in the field; such instruction could highlight decision strategy.

INSTRUCTION OBSERVATION DATA
Course No. 40104

Course # 40104 Short Title Diesel Eng

Date/Time of Observation 12 Aug 71 0700 Duration 2 hr Type Lec

Lesson Plan # or other content identifier Inet Sprague VR

Previous No. of meetings of this section 24

No. of Assistants 0

No. of Students 9

1. Relevant Training Outcomes

Analyze, service, and adjust the voltage regulator.

Comments

Not maintenance Concept valid.

2. Objectives of Lesson/Lab

Not stated

Comments

3. Instructor Guides

Daily topic outline available only, consisting of "Solid State Review" and "Inet Sprague Transistorized Voltage Regulator" topics. No objectives listed, no aids, no references.

Comments

4. Student Guides/Workbooks

Available, in use, applicable.

Comments

5. Instructors

No indication given what students should be expected to do as result of instruction. Ample interim summaries and repetition of key points. Review of solid state apparently conducted in earlier class.

Comments

6. Laboratories

Comments

(Not applicable)

7. Overall comments and suggestions for improvement

Increase emphasis on failure effect analysis and maintenance aspects. Need a better simplified explanation of purpose and function of groups of components before plunging into description of what each does individually.

Course # 40104 Short Title Diesel Eng

Date/Time of Observation 12 Aug 71 1130 Duration 2 hr Type Laboratory

Lesson Plan # or other content identifier Inet Sprague VR measurements

Previous No. of meetings of this section 26

No. of Assistants 1

No. of Students 9

1. Relevant Training Outcomes

   Analyze, service, and adjust the voltage regulator.

   Comments

   Not Maintenance Concept valid.

2. Objectives of Lesson/Lab

   None stated.

   Comments

3. Instructor Guides

   Lesson plan consists of lab exercise sheets instructing students to make certain measurements.

   Comments

4. Student Guides/Workbooks

   Students used lab exercise sheets to perform lab.

   Comments

5. Instructors

   Stayed relatively close to students and gave assistance when requested.

   Comments

6. Laboratories

Comments

Students worked in groups. Some had actual regulators; others had breadboard models. Instructor taught how to tell positive lead of ohmmeter.

7. Overall comments and suggestions for improvement

Course materials need improvement. Lesson plans should be prepared and objectives, student outcomes clearly stated. Erroneous, and incomplete wiring diagrams should be corrected. Observation of student performance leads to conclusion that those observed didn't know how to use schematic and wiring diagram information to identify parts and locate leads or terminals at which to make measurements. The lab was primarily an exercise in the use of the ohmmeter. Vender supplied documentation was generally poor. The course personnel should supplement it with school-produced materials (parts location diagrams, wiring diagrams and schematics).

Course # 40104 Short Title Diesel Eng

Date/Time of Observation 17 Aug 71 0900 Duratino 2 hr Type Lecture

Lesson Plan # or other content identifier Diesel Engine Test Equipment

Previous No. of meetings of this section 37

No. of Assistants 0

No. of Students 9

1. Relevant Training Outcomes

Perform preventive and corrective maintenance tests, performance checks, and adjustments of the engine generator.

Comments

Not Maintenance Concept valid.

(Discussion was on test equipment)

2. Objectives of Lesson/Lab

Not stated.

Comments

Lesson plan is topic outline for day; does not list objectives.

3. Instructor Guides

None available. Only guide was daily outline.

Comments

4. Student Guides/Workbooks — Comments

Available, in use, applicable.

5. Instructors — Comments

An animated film on diesel engines was presented. Probably developed for vocational school types. Elementary in presentation. Some discussion given to compression tester. Some discussion given to flow of fuel and storage tanks and maintenance thereof. No appraisal of student performance or grasp of content attempted.

6. Laboratories — Comments

(Not applicable)

7. Overall comments and suggestions for improvement

Write lesson plans in greater detail and include student outcomes. Stay with lesson plan and assess student achievement. Withdraw film; too elementary. Probably too much time allocated to test equipment lecture.

Course # 40104 Short Title Diesel Eng

Date/Time of Observation 17 Aug 71 1130 Duration 2 hr Type Lab

Lesson Plan # or other content identifier Experiment #4

Previous No. of meetings of this section 38

No. of Assistants 1

No. of Students 9

1. Relevant Training Outcomes — Comments

Perform preventive and corrective maintenance tests, performance checks, and adjustments of the engine generator.

Not Maintenance Concept valid.
(Lab devoted to engine checks)

2. Objectives of Lesson/Lab

Comments

To gain experience in evaluation and performance of diesel engine generators

(from Lab Exercise sheets)

3. Instructor Guides

Comments

None. Only lab exercise sheets available.

4. Student Guides/Workbooks

Comments

Lab exercise sheets available to structure laboratory

5. Instructors

Comments

Instructor was pressed into service due to unanticipated personnel shortage. Had not taught the laboratory previously. Short lab briefing conducted with reference to potential hazards.

6. Laboratories

Comments

Recording voltage, frequency meter explicitly not to be covered but called for by lab instructions. Torque wrenches not immediately on hand.

7. Overall comments and suggestions for improvement

Lab instruction sheets should include a stop direction prior to attempting to make compression measurements so that instructor can verify that fuel high pressure pumps have been disabled. Accident did not happen, but potential is present. Revise instructions to omit recording volt/frequency meter data if not to be used. Instructions on how to select proper compression tester fixture should be given.

INSTRUCTION OBSERVATION DATA
Course No. 40115

Course # 40115 | Short Title SSF

Date/Time of Observation 18 Aug 71 0700 | Duration 4 hr Type Lec

Lesson Plan # or other content identifier Junction Transistor Servicing

Previous No. of meetings of this section 20

No. of Assistants 0

No. of Students 17

1. Relevant Training Outcomes

   Recognize malfunctions in typical circuits, analyze and localize the malfunctions, and replace the defective solid-state devices in the circuit without damaging the new device or circuit.

   Comments

   Not Maintenance Concept valid.

2. Objectives of Lesson/Lab

   Junction Transistor Servicing
   A. Transistor lead identification.
   B. Out of circuit testing of junction transistors.
      Ohmmeter testing.
      Ohmmeter testing for Beta.
   C. In circuit testing of Junction Transistors

   Comments

   (From course outline. No formal lesson plan exists . . . course programmed.)

3. Instructor Guides

   Uses programmed text.

   Comments

   Instructor deviated from text sequence.

4. Student Guides/Workbooks

   Students use same programmed text.

   Comments

   Text does not contain answers to questions.

5. Instructors | Comments

Introduction given but no student outcomes stated. Good work on interim and final summaries. Very effective use of viewgraphs and sketch work. Many practical tips provided on soldering and desoldering components.

6. Laboratories | Comments

(Not applicable)

7. Overall comments and suggestions for improvement

Programmed texts provide answers to questions. In this instance the answers are not given to the students. This probably results from the text's being used in conjunction with student responders in class. Students could insert the correct answers in advance if available to them, thus defeating an objective of the responders. One solution is to prepare an additional set of questions related to the same topics for use in class, and give the students the answers to the other set in the book. This solution satisfies both objectives; immediate reinforcement in the self-study mode, and instructor monitoring of rate of learning by group in the class responder mode.

Course # 40115 Short Title SSF

Date/Time of Observation 18 Aug 71 1130 Duration 4 hr Type Lab

Lesson Plan # or other content identifier Lab exercise #4

Previous No. of meetings of this section 22

No. of Assistants 1

No. of Students 19

1. Relevant Training Outcomes | Comments

Understand the theory of operation of diodes, Zener diodes, transistors, unijunction transistors, silicon-controlled rectifiers, and silicon-controlled switches.	Not Maintenance Concept valid
Operate all related test equipment and tools.	Not Maintenance Concept valid.

2. Objectives of Lesson/Lab | Comments

None listed.

3. Instructor Guides | Comments

Consists of course schedule.

4. Student Guides/Workbooks | Comments

Exercises are in packets of instructions containing transistor characteristics and graphic materials as well as directions.

5. Instructors | Comments

Respond to questions when asked, relatively uninvolved.

6. Laboratories | Comments

Students work in pairs, on different experiments, at own pace. Difficult for lab instructor to make general comments since different experiments are in process. Students develop facility in using test equipment. Too bad the lab wasn't on soldering or servicing junction transistors (lecture immediately preceding).

7. Overall comments and suggestions for improvement

Tighter control of lab is necessary. No obvious reason why all students can't work on same lab at same time. Better correlation of lab with lecture desirable; immediate application of knowledge by lab practice. Closer monitoring of student progress required. This particular lab could be converted into a demonstration with the instructor taking the reading and students working up their own calculations, releasing equipment space, personnel, and time.

INSTRUCTION OBSERVATION DATA
Course No. 40200

Course # 40200 | Short Title TACAN Principles

Date/Time of Observation 11 Aug 71 1130 | Duration 2hr | Type Lecture

Lesson Plan # or other content identifier Astable Multivibrator

Previous No. of meetings of this section 142

No. of Assistants 0

No. of Students 14

1. Relevant Training Outcomes

   Recognize and evaluate the wave-shaping amplification, and pulse circuitry in the TACAN equipment.

   Comments

   Not Maintenance Concept valid.

2. Objectives of Lesson/Lab

   Qualitative Analysis . . . understand the transitions through which this circuit passes . . . Quantitative Analysis . . . understands the operation of the astable multivibrator and is able to evaluate any circuit of this type found in the Rho-Theta Navigation equipment.

   Comments

   Students not required to demonstrate their understanding.

3. Instructor Guides

   Available, but do not indicate specific projectuals, or other aids to be used.

   Comments

4. Student Guides/Workbooks

   Available, in use, and applicable.

   Comments

5. Instructors

   Instructor should introduce the lesson, stating objectives and expected student outcomes.

   Comments

6. Laboratories

   Not applicable.

   Comments

7. Overall comments and suggestions for improvement

An attempt should be made to relate the subject matter to maintenance actions or job requirements. Obtain and use training film on multi-vibrator action.

Course # 40200 Short Title TACAN Principles

Date/Time of Observation 12 Aug 71 0900 Duration 2 hr Type Lab

Lesson Plan # or other content identifier ASTABLE MULTIVIBRATOR LAB

Previous No. of meetings of this section 145

No. of Assistants 1

No. of Students 15

1. Relevant training Outcomes — Comments

Recognize and evaluate the waveshaping amplification and pulse circuitry in the TACAN equipment.

Not Maintenance Concept valid

2. Objectives of Lesson/Lab — Comments

To observe the effects on changes in circuit components values and voltages upon circuit waveforms. To compare the results of circuit calculations with circuit observations.

3. Instructor Guides — Comments

Lesson guide and lab exercise provide detailed instructions on how to proceed.

4. Student Guides/Workbooks — Comments

Lab exercise instruction sheet provides detailed instructions on how to proceed.

5. Instructors — Comments

Closer supervision and interaction with students desirable.

6. Laboratories

Comments

Closer supervision and interaction with students desirable.

7. Overall comments and suggestions for improvement

This laboratory exercise could be improved by redirecting its emphasis. At present, it emphasizes the effects of changes in circuit values. It would be better if it emphasized what components could be responsible for observed out of tolerance conditions. However, the lab could probably be replaced by a demonstration, since students by this time know how to use test equipment.

INSTRUCTION OBSERVATION DATA
Course No. 40210

Course # 40210 Short Title VHF/UHF DF

Date/Time of Observation 13 Aug 71 1130 Duration 2 hr Type Lab

Lesson Plan # or other content identifier 8-3, 8-4

Previous No. of meetings of this section 30

No. of Assistants 0

No. of Students 7

1. Relevant Training Outcomes

   Evaluate the operation and performance of the equipment.
   Diagnose and correct equipment malfunctions.
   Properly use all facility test equipment.

   Comments

   Isolation of failed components; not correct malfunctions.

   Job Analysis document valid training outcomes (all three)

2. Objectives of Lesson/Lab

   Student Outcomes:
   1. Recognize, analyze, and isolate a minimum of four system troubles . . . isolate to component level in specified time.
   2. Obtain an overall grade average of 70% on the number of troubles completed (minimum acceptable is four).

   Comments

   This was a performance exam.

3. Instructor Guides

   Available, but did not cite specific schematics to use.

   Comments

4. Student Guides/Workbooks

   Available, applicable and used.

   Comments

5. Instructors

Good introduction and monitoring, administration of exam.

Comments

6. Laboratories

(See above)

Comments

7. Overall comments and suggestions for improvement

Thirty points of the exam were dedicated to grading the student's use of test equipment, restoring equipment, and general clean-up. In my opinion, this weight for these factors is too high at this point in the course and constitutes a cushion or gift: reduce the weight and redistribute. Construct and distribute the paper and pencil problems to students waiting to be tested, as called for by the lesson plan.

Course # 40210 Short Title VHF/UHF DF

Date/Time of Observation 13 Aug 71 0900 Duration 2 hr Type Lec

Lesson Plan # or other content identifier p/o 8-2a, 8-2b

Previous No. of meetings of this section 29

No. of Assistants 0

No. of Students 7

1. Relevant Training Outcomes

Evaluate the operation and performance of the equipment.

Comments

(Enabling knowledges only)

Job Analysis Document valid.

2. Objectives of Lesson/Lab

Student will be able to:

1. Make a circuit analysis of the reference generator.
2. Explain the phase detectors.
3. Analyze the bearing processing circuits.
4. Explain the operation of the intensity gate.
5. Explain the operation of the blanking circuit.

Comments

2. Objectives of Lesson/Lab (Continued)

6. Give a general description of the purpose and function of the remote indicator.
7. Make a comparison of the local indicator and the remote indicator.
8. Describe in detail the circuitry of the remote indicator.

3. Instructor Guides

Comments

Available, but did not contain identification of which schematic diagram to use.

4. Student Guides/Workbooks

Comments

Available, applicable and used

5. Instructors

Comments

No attempt made to determine if lesson objectives were met other than by asking if there were any questions.

6. Laboratories

Comments

(Not applicable)

7. Overall comments and suggestions for improvement

Ample time was available for the instructor to determine if the objectives of the lesson were being achieved and to take remedial action if they were not. Greater emphasis should be placed on the maintenance aspects of the equipment. Interim and final summaries should be made.

Course # 40210 Short Title VHF/UHF DF

Date/Time of Observation 10 Aug 71 1330 Duration 2 hr Type Lab

Lesson Plan # or other content identifier 5-3, 5-4

Previous No. of meetings of this section 17

No. of Assistants 0

No. of Students 7

1. Relevant Training Outcomes

   Evaluate the operation and performance of the equipment. Perform maintenance checks and adjustment in accordance with current operating standards. Properly use all facility test equipment.

   Comments

   Job Analysis document valid.

2. Objectives of Lesson/Lab

   1. Perform precision phase shift oscillator tuning adjustments.
   2. Perform data extractor oscillator adjustment.
   3. Orient the system to a known target.
   4. Evaluate the preciseness of the system alignment.

   Comments

   Student lab exercise guide provides instructions on how to perform experiment.

3. Instructor Guides

   Available but contained only six phrases, and did not list equipment required.

   Comments

   Student lab exercise guide contains details.

4. Student Guides/Workbooks

   Available and in use.

   Comments

   Students detected error in instructions which could stop experiment unless instructor intervened.

5. Instructors

   Assistant not required.

   Comments

   Closer monitoring of students' progress with attention to achievement of lab exercise goals is desirable.

6. Laboratories

All aids and devices were available in sufficient quantities.

Comments

Only two counters were available but not needed continuously, so were time-shared by students.

7. Overall comments and suggestions for improvement.

The error detected by students in the procedures suggests that the instructor might learn how to correct it and possible others by attempting to perform the exercise himself using only the lab exercise guide. Greater interaction with students and the use of summaries would help. Equipment utilized was that to be maintained . . . no substitute seems reasonable.

Course # 40210

Short Title VHF/UHF DF

Date/Time of Observation 10 Aug 71 0700

Duration 2 hr Type Lec

Lesson Plan # or other content identifier 5-1

Previous No. of meetings of this section 16

No. of Assistants 0

No. of Students 7

1. Relevant Training Outcomes

Evaluate the operation and performance of the equipment

Comments

(Presentation of enabling knowledges only)

Job Analysis document valid.

2. Objectives of Lesson/Lab

Student will be able to:
1. Draw and explain the receiver block diagram.
2. Give a general description of the rcvr.
3. Explain the difference between VHF & UHF front ends.
4. Explain the operation of mechanical selector mechanism.
5. Make a detailed analysis of the rcvr.

Comments

Instructor made no explicit references to objectives during lesson in terms of what students were expected to do.

2. Objectives of Lesson/Lab (Continued)

   6. Define the purpose of the control oscillator in depth, the circuitry that controls Osc Freq.
   7. Discuss features of delayed AGC circuitry.
   8. Explain purpose of data extractor and show how it pertains to the DF system.

3. Instructor Guides — Comments

   Although lesson plan was available, instructor spoke from notes

4. Student Guides/Workbooks — Comments

   Available, in use

   Comments: Students followed lecture on own schematics.

5. Instructors — Commants

   Omitted planned content.

   Comments: Channel selection details omitted although in L.P. If covered earlier, at best out of sequence.

6. Laboratories — Comments

7. Overall comments and suggestions for improvement

   Lesson could be improved by closer adherence to lesson plan; presentation of introduction, statement of student outcomes, and effort to determine through student demonstration that outcomes have been achieved, and use of interim and final summaries.
   Ample opportunity exists to address effects of failed components in the context of describing circuit operation.

INSTRUCTION OBSERVATION DATA
Course No. 40216

Course # 40216 Short Title Wilcox

Date/Time of Observation 20 August 0900 Duration 2 hr Type Lab

Lesson Plan # or other content identifier Monitor adjustments

Previous No. of meetings of this section 89

No. of Assistants 0

No. of Students 11

1. Relevant Training Outcomes

   Perform all maintenance checks and adjustments.

   Comments

   Not Maintenance Concept valid.

2. Objectives of Lesson/Lab

   To determine and adjust the monitor tolerances.

   Comments

   Objectives are from lab instructions;
   No lesson guide available.

3. Instructor Guides

   None available.

   Comments

   Lab instructions provide details on performance of lab exercise.

4. Student Guides/Workbooks

   Available, but not used.

   Comments

   Majority of class was outside building at V ring array.

5. Instructors

   The instructor provided a good introduction to the lab. However, not all equipment had been made ready prior to start of lab, causing some delay.

   Comments

6. Laboratories

   Adequate pole climbing safety harness was not available.

   Comments

7. Overall comments and suggestions for improvement.

Instructor should make ready before lab begins. Safety harness deficiency should be corrected. The laboratory was actually a demonstration. Most of the students could do no more than watch. A film or video tape would do as well, and perhaps better.

Course # 40216 Short Title Wilcox

Date/Time of Observation 20 Aug 71 0700 Duration 2 hr Type Lecture

Lesson Plan # or other content identifier Wilcox Monitor adjustments

Previous No. of meetings of this section 88

No. of Assistants 0

No. of Students 11

1. Relevant Training Outcomes

   Perform all maintenance checks and adjustments.

   Comments

   Not Maintenance Concept valid.

2. Objectives of Lesson/Lab

   No formal lesson plan.

   Comments

   Instructor uses hand-written notes to lecture from

3. Instructor Guides

   None available

   Comments

   Prototype course has not yet been conducted

4. Student Guides/Workbooks

   Available.

   Comments

   Students follow instructor in schematics

5. Instructors

   Insufficient attention to determining if students understood presentation, no interim or final summaries.

   Comments

6. Laboratories

   Comments

(Not applicable)

7. Overall comments and suggestions for improvement

The presentation could be improved greatly through using mockups or other training aid in going through the calibration procedures. More emphasis should be placed on maintenance aspects.

Course # 40216 Short Title Wilcox

Date/Time of Observation 17 Aug 71 1330 Duration 2 hr Type Lab

Lesson Plan # or other content identifier Tune Localizer, Glide Slope familiarization with Monitor Detector

Previous No. of meetings of this section 79

No. of Assistants 1

No. of Students 11

1. Relevant Training Outcomes — Comments

   Perform all maintenance checks and adjustments. — Not Maintenance Concept valid.

2. Objectives of Lesson/Lab — Comments

   Tune localizer.
   Tune Glide Slope.
   Become familiar with Monitor Detector.

   No lesson plan; objectives are from lab exercise guide.

3. Instructor Guides — Comments

   Only laboratory exercise guide.

4. Student Guides/Workbooks — Comments

   Lab exercise guide provides procedure to follow. — No provision made for students to record observations.

5. Instructors — Comments

   Instructors check frequently with students to monitor progress and correct errors.

6. Laboratories — Comments

   No laboratory performance examinations given in this course.

7. Overall comments and suggestions for improvement

Practical exercises in troubleshooting and performance tests should be constructed for this course. An increased maintenance emphasis is needed.

INSTRUCTION OBSERVATION DATA
Course No. 40318

Course # 40318 Short Title ATCBI-3

Date/Time of Observation 13 Aug 71 0700 Duration 2 hr Type Lecture

Lesson Plan # or other content identifier Lecture #7

Previous No. of meetings of this section 28

No. of Assistants 0

No. of Students 13

1. Relevant Training Outcomes

Isolate faults to individual components.

Comments

(Enabling knowledge only) Job Analysis document valid. Not Maintenance Concept valid.

2. Objectives of Lesson/Lab

(Instructor worked from own notes, lesson plan out of date, not related to content discussed in class.)

Comments

3. Instructor Guides

Out-of-date guide. Instructor spoke from own notes and schematic diagram which students followed in their own books.

Comments

4. Student Guides/Workbooks

Available, in use, applicable.

Comments

5. Instructors

Content of lesson consisted chiefly of tracing signal flow through schematic diagram. No attempt to determine if students could do likewise. No emphasis on maintenance aspects. No use of viewgraphs.

Comments

6. Laboratories

Comments

(Not applicable)

7. Overall comments and suggestions for improvement

Statement of student outcomes required. Assessment of achievement of outcomes required. Viewgraphs would eliminate need for instructor to draw diagrams on chalkboard. Emphasize maintenance aspects during presentation.

Course # 40318

Short Title ATCBI-3

Date/Time of Observation 13 Aug 71 1330

Duration 2 hr Type Lab

Lesson Plan # or other content identifier Lab #3, Pulse Mode Generator

Previous No. of meetings of this section 31

No. of Assistants 1

No. of Students 6

1. Relevant Training Outcomes

Use general and special test equipment to analyze system performance and to isolate faults. Check calibration and determine accuracy of all test equipment.

Comments

(To analyze system performance and to isolate only to defective stage, not component)

Job Analysis document valid.
Not Maintenance Concept valid.

2. Objectives of Lesson/Lab

To allow students to make any adjustments on or to observe any waveforms he thinks are important. Also circuits are analyzed through malfunctions.

Comments

(From lesson plan)

Malfunctions are caused by removing tubes.

3. Instructor Guides

Available.

Comments

4. Student Guides/Workbooks — Comments

Lab instructions prescribe work to be done; however they describe what adjustments do but do not direct students to perform any action or make notes on their observations. No reference made to standard waveforms to be observed (waveform guides).

5. Instructors — Comments

Two instructors work with a group of 3 students each. Instructors provide very close guidance in structuring student behavior.

6. Laboratories — Comments

Not all students make all adjustments. Malfunctions inserted by tube removal probably acceptable at this stage of training. Despite appearance of freedom to choose waveforms to examine, students follow guidance in lab instructions.

7. Overall comments and suggestions for improvement

As conducted, this laboratory could be replaced by a demonstration. Presently, one student in the 3-man group practices using the oscilloscope and operating switches on the front panel; others watch. Practice in interpreting symptom patterns and using schematics could be done on a mockup. Waveform guides are needed.

Course # 40318 Short Title ATCBI-3

Date/Time of Observation 19 Aug 71 0700 Duration 2 hr Type Lecture

Lesson Plan # or other content identifier Lesson #13

Previous No. of meetings of this section 44

No. of Assistants 0

No. of Students 13

1. Relevant Training Outcomes

Isolate faults to individual components.

Comments

(Enabling knowledges only)

Job Analysis document valid.
Not Maintenance Concept valid.

2. Objectives of Lesson/Lab

Student should be able to:
1. Understand the term fruit.
2. Understand the effects of fruit on beacon system.
3. Analyze the trigger circuits.

Comments

(From Lesson Plan)

3. Instructor Guides

Available, but short . . . a topic outline.

Comments

4. Student Guides/Workbooks

Available, in use, applicable

Comments

Used schematic diagrams.

5. Instructors

Inverted topic sequence. No attempt to determine if student outcomes achieved through student demonstration. Poor use of summaries. Hypothesized failed part, required students to deduce consequences.

Comments

6. Laboratories

Comments

(Not applicable)

7. Overall comments and suggestions for improvement,

Statement of objectives should be made regardless of whether this period was a continuation of material introduced earlier or not. Attempts should be made to assess student achievement of objectives. Attempt at paper troubleshooting was good, but should be inverted by giving the symptoms of the failure and requiring students to logically isolate the fault, rather than by giving the fault and requiring deduction of the symptoms.

INSTRUCTION OBSERVATION DATA
Course No. 42002

Course # 42002 Short Title ARTS III

Date/Time of Observation 16 Aug 1330 Duration 2 hr Type Lecture

Lesson Plan # or other content identifier Familiarization with programming

Previous No. of meetings of this section 175

No. of Assistants 0

No. of Students 14

1. Relevant Training Outcomes

   Analyze, interpret, and modify printouts of operational, maintenance, utility, and diagnostic programs as required.

   Comments

   (Not Maintenance Concept validated)

2. Objectives of Lesson/Lab

   Practice in programming.

   Comments

   Objective obtained from instructor . . . not l.p.

3. Instructor Guides

   None available.

   Comments

   Instructor works from notes.

4. Student Guides/Workbooks

   Available, in use, applicable

   Comments

5. Instructors

   Seemed well prepared for lesson. Students spent much time working separately. Last portion of lesson consisted of presentation of program prepared by instructor, and explanation thereof.

   Comments

6. Laboratories

   Comments

   (Not applicable)

7. Overall comments and suggestions for improvement

Formal lesson plan is needed for this lesson, stating student outcomes objectives, etc. More effort needs to be made to determine that students can actually perform to required actions. Greater student instructor interaction required to ensure that students are actually writing program and that mistakes in procedures can be detected by instructor.

Course # 42002 Short Title ARTS III

Date/Time of Observation 16 Aug 71 0700 Duration 2 hr Type lecture

Lesson Plan # or other content identifier I/O Sequences F62 instruction

Previous No. of meetings of this section 172

No. of Assistants 0

No. of Students 13

1. Relevant Training Outcomes

   Understand circuit, subsystem, and overall system operation of the ARTS III equipment.

   Comments

   Not Maintenance Concept valid.

2. Objectives of Lesson/Lab

   Explanation of F62.

   Comments

   Objectives not documented only stated by instructor.

3. Instructor Guides

   No lesson guides available.

   Comments

   Instructor works from notes.

4. Student Guides/Workbooks

   Available, in use, applicable.

   Comments

5. Instructors

   Describes how hardware performs F62 using diagrams in workbooks. Corrected error on timing chart in class.

   Comments

6. Laboratories

   Comments

(Not applicable)

6. Laboratories

Comments

Groups of 4 students watched the instructor set up two problems and work through them. Students did not actually set up the problems themselves. This was a demonstration, and could have been done in another way.

7. Overall comments and suggestions for improvement

Lesson plan should be prepared for this lesson. No student outcomes identified. Purpose of demonstration could be achieved through using slide tape show or video tape, or even paper mockup, releasing equipment for more important use.

Course # 42002

Short Title ARTS III

Date/Time of Observation 10 Aug 71 0900

Duration 2 hr Type lecture

Lesson Plan # or other content identifier IOP Arithmetic Unit

Previous No. of meetings of this section 158

No. of Assistants 0

No. of Students 15

1. Relevant Training Outcomes

Understand circuit, subsystem, and overall system operation of the ARTS III equipment.

Comments

Not Maintenance Concept valid.

2. Objectives of Lesson/Lab

Not stated.

Comments

No lesson plan exists.

3. Instructor Guides

None exists.

Comments

Instructor speaks from personal notes.

4. Student Guides/Workbooks

Available, in use, applicable.

Comments

7. Overall comments and suggestions for improvement

Emphasis should be placed on how this information is used in maintenance. Errors should be corrected in materials. Attempts should be made to determine that students know what has been taught. Student outcomes should be identified. Formal lesson plan should be prepared.

Course # 42002 Short Title ARTS III

Date/Time of Observation 10 Aug 71 1130 Duration 2 hr Type Lab

Lesson Plan # or other content identifier Arithmetic Unit

Previous No. of meetings of this section 159

No. of Assistants 0

No. of Students 15 (groups of 4)

1. Relevant Training Outcomes

   Locate and identify all sub-assemblies and controls.

   Recognize, analyze, localize, and correct all deficiencies and malfunctions.

   Comments

   Maintenance Concept valid.

   Not Maintenance Concept valid.

2. Objectives of Lesson/Lab

   Not stated in lesson plan.

   Comments

   No formal lesson plan. Instructor demonstrated multiplication/division with hardware.

3. Instructor Guides

   No lesson plan.

   Comments

   Instructor works from memory.

4. Student Guides/Workbooks

   Workbooks available, used to follow instructor actions.

   Comments

5. Instructors

   Good work in the demonstration. Attempted to show what had been covered in lecture (monitored same).

   Comments

5. Instructors

Comments

Used personal notes; students followed in student guide. Used viewgraphs. Reviewed materials, but gave no preparation for lab which followed.

6. Laboratories

Comments

(Not applicable)

7. Overall comments and suggestions for improvement

Error detected in diagram page 308 study guide (M) II D4 (FR-630-1) vol 1 of 4 was corrected in class; should be corrected on master. Emphasis should be placed on how to relate lecture material to maintenance requirements. Attempts should be made to determine that students have learned lesson material. Formal lesson plans should be prepared with specific identification of student outcomes, training aids to be used.

INSTRUCTION OBSERVATION DATA
Course No. 43411

Course # 43411 Short Title I/O for Technicians

Date/Time of Observation 12 Aug 71 1330 Duration 2 hr Type Examination

Lesson Plan # or other content identifier Exam #1 FSPCM

Previous No. of meetings of this section 27

No. of Assistants 0

No. of Students 16

1. Relevant Training Outcomes — Comments

   Trace logic signals from input to output and understand logic functions of the 7289-03 Flight Strip Printer Control Module.

   Comments: Not Maintenance Concept valid.

2. Objectives of Lesson/Lab — Comments

   (Not stated)

3. Instructor Guides — Comments

   No guide available for the administration of exams.

4. Student Guides/Workbooks — Comments

   Each student was permitted to use any materials desired . . . open book.

5. Instructors — Comments

   Monitored exam appropriately.

6. Laboratories — Comments

   (Not applicable)

7. Overall comments and suggestions for improvement

The examination (20 multiple choice questions) appeared appropriate to the material presented in lecture. But the lecture material should be revised to teach only that which can be supported by actual maintenance requirements. The exam itself then should be revised to reflect this new orientation.

Course # 43411 Short Title I/O for Technicians

Date/Time of Observation 11 Aug 71 0900 Duration 2 hr Type Lab

Lesson Plan # or other content identifier Lab Experiment #3

Flight strip printer 1980-1

Previous No. of meetings of this section 21

No. of Assistants 1

No. of Students 16

1. Relevant Training Outcomes

   Disassemble and reassemble parts, make mechanical adjustments, and understand the operation and electrical circuitry of the 1980 flight strip printer.

   Comments

   Not Maintenance Concept valid.

2. Objectives of Lesson/Lab

   With the aid of the laboratory procedures the student will be able to align the entire tilt and rotate systems.

   Comments

3. Instructor Guides

   Not available in lab, but exists. Briefing not normally given prior to each lab. Does not call for specific training aids.

   Comments

4. Student Guides/Workbooks

   Available, in use and applicable.

   Comments

5. Instructors

Comments

Instructor checks with students periodically to answer questions and resolve problems.

6. Laboratories

Comments

Students work at their own pace on different exercises, so no common structure is possible. Lab exercise requires practice making adjustments on specific equipments . . . no substitute possible.

7. Overall comments and suggestions for improvement

All students should be working on the same lab exercise simultaneously facilitiating administration and teaching.

FP-160/165-1 FSP maintenance manual could be more highly proceduralized.

Course # 43411 Short Title I/O for Technicians

Date/Time of Observation 11 Aug 71 1330 Duration 2 hr Type Lecture

Lesson Plan # or other content identifier Echo Check Logic

Previous No. of meetings of this section 23

No. of Assistants 0

No. of Students 15

1. Relevant Training Outcomes

Comments

Trace logic signals from input to output and understand logic functions of the 7289-03 Flight Strip Printer Control Module (FSPCM).

Not Maintenance Concept valid.

2. Objectives of Lesson/Lab

Comments

Student will know:
The logic of the function decoders.
The logic of the Invalid Function code detection.
Purpose of the C.U. Diagnostic code.
Will increase proficiency in reading second level timing charts and flow diagrams.

3. Instructor Guides — Comments

Lesson guide exists but not present in classroom. Instructor teaches from notes.

4. Student Guides/Workbooks — Comments

Students used guides/workbooks to follow presentation.

5. Instructors — Comments

Deviated from lesson guide; no reference to desired student outcomes; minimal use of interim summaries

6. Laboratories — Comments

(Not applicable)

7. Overall comments and suggestions for improvement

The diagrams could be greatly improved by emphasizing critical main data paths and their relationships. However, physical structure of hardware (modules on printed circuit cards) suggest that an ability to isolate to an individual logic element conceptually cannot be realized in practice. Repair consists of replacement of the card containing the bad and good modules.

Emphasis should be placed upon determining what could be wrong when inputs are present but outputs are bad.

Students should be required to demonstrate their knowledge of the logic during the lecture so that the instructor can detect and correct their errors.

INSTRUCTION OBSERVATION DATA
Course No. 43413

Course # 43413 Short Title 9020

Date/Time of Observation 16 Aug 71 2000 Duration 4 hr Type Lecture

Lesson Plan # or other content identifier FP250 PAM L.P. 1

Previous No. of meetings of this section 494

No. of Assistants 0

No. of Students 15

1. Relevant Training Outcomes

Trace operation of the Peripheral Adapter Module (PAM) through addressing, priority, configuration, and interface circuits.

Comments

Not Maintenance Concept valid.

2. Objectives of Lesson/Lab

PAM
1. Review
2. Power on
3. CE/PAM interface
4. Manual configuration
5. SCON instruction

Comments

(From chalkboard)

Lesson Plan has no student outcomes listed.

3. Instructor Guides

Available, but does not indicate proportion of time to be spent on each subject. (Items 4 & 5, above, were deferred until next day.)

Comments

4. Student Guides/Workbooks

Available, in use, applicable

Comments

5. Instructors

There is so little detail in lesson plan that it is hard to tell if instructor is staying with it. No appraisal of student achievement of objectives.

Comments

6. Laboratories

Comments

(Not applicable)

7. Overall comments and suggestions for improvement

Power up discussion is of a procedure and should be in a step-by-step format. Lecture method is very slow and not especially clear. Emphasis should be placed upon maintenance aspects. It could be integrated with the discussion.

Course # 43413 Short Title 9020

Date/Time of Observation 16 Aug 71 1730 Duration 2 hr Type Lab

Lesson Plan # or other content identifier System console & PAM

Previous No. of meetings of this section 493

No. of Assistants 1

No. of Students 15

1. Relevant Training Outcomes

Operate the IBM-9020 System both from the Element Maintenance Panels and from the System Console; configure a system and make it ready for operation; load a source program to obtain listings; and load an object program for execution.

Comments

Job Analysis document valid.

2. Objectives of Lesson/Lab

To enable the student to use the CE Panel of PAM.
To perform some of the immediate commands to an adapter and to monitor the resulting latch operations.

Comments

From Pam Lab Ex #3

3. Instructor Guides

Lab exercise sheets prescribe procedure to use.

Comments

4. Student Guides/Workbooks — Comments

Available, but students used lab exercise sheets which prescribed the sequence of switches to activate and resulting displays.

5. Instructors — Comments

Could have spent more time with students, assessing progress and their knowledge of what they were doing.

6. Laboratories — Comments

Students worked in groups of three each. One group on system console experiment, other group on PAM experiment. Remainder worked on paper problems.

7. Overall comments and suggestions for improvement

Because of the high degree of proceduralization of the lab exercise, it could be accomplished through the use of a relatively low cost mockup. That is, the procedures could be learned and practiced on the mockup with checkout on the equipment, releasing the computer facility for higher priority operations.

Course # 43413 — Short Title 9020

Date/Time of Observation 16 Aug 71 1530 — Duration 2 hr Type Lec

Lesson Plan # or other content identifier System Console Lesson #3

Previous No. of meetings of this section 492

No. of Assistants 0

No. of Students 15

1. Relevant Training Outcomes — Comments

Trace the operation of the control units which interconnect the system oriented I/O devices to the IOCE channels.

Not Maintenance Concept or Job Analysis document valid.

2. Objectives of Lesson/Lab — Comments

Continuation of Initial Selection Sequence simulation using CE Panel

A. Review & Question on ISS
B. ISS cont.
   1. IOCE verifies address. (From lesson guide)
   2. IOCE places command on bus out.
   3. IOCE raises CMD out.
   4. CCU decodes command.
   5. CCU status on Bus in.
   6. Status in delayed to IOCE
      IOCE raises SVC out
      Terminate ISS, Reset latches.
C. ISS Latch
D. SC Lab #3 briefing

3. Instructor Guides — Comments

Available. References to ALDS but not viewgraphs and other aids.

4. Student Guides/Workbooks — Comments

Available, in use, applicable.

5. Instructors — Comments

Primary emphasis was on tracing data paths through ILDs and ALDs. Students annotated diagrams with remarks and levels as discussion proceeded. No interim summaries. Did not determine if students could trace logic on diagrams.

6. Laboratories — Comments

(Not applicable)

7. Overall comments and suggestions for improvement

Students claim to be able to use ALDs. If so, considerable timesavings could be had by eliminating the detail tracing of logic through diagrams. If, because of packaging of hardware, lack of spare modules, or policy prohibiting removal of soldered-in module from card, technicians in field isolate to card level only, then ability to identify which module failed is not required. Emphasis should then be on which cards to replace. More emphasis should be placed on the identification of failures from the analysis of resulting symptom patterns. It should be done in the context of tracing the logic of normally operating components rather than deferring it to some later portion of the course.

Appendix B

ADMINISTRATIVE AND INSTRUCTIONAL MATERIALS

HUMAN RESOURCES RESEARCH ORGANIZATION
DIVISION NO. 1

4 October 1971

MEMORANDUM TO: Mr. Arthur Fillebrown

FROM: P.J. Butler

SUBJECT: Request of data from FAA
Per our telephone conversation 4 October, 1971

1. The following data were requested:

   a. Identification of training costs of contractor conducted training programs for ANF instructors and/or key cadre personnel.

   b. Identification of training costs of the same programs identified in (a) above for ANF conducted training programs for their instructors and/or key cadre personnel.

   c. Identification of training programs and costs where the contractor developed and provided the training materials to ANF but did not conduct the training programs.

2. The deadline for furnishing these data was specified as COB Thursday, October 7, 1971.

P.J. Butler
Research Scientist

PJB/pe

HUMAN RESOURCES RESEARCH ORGANIZATION
DIVISION NO. 1

5 October 1971

MEMORANDUM OF TELEPHONE CALLS

FILE: AVCAD

FROM: Mr. John von Ancken, FAA

SUBJECT: Cost Data Request

1. In response to cost data requests made by telephone to Mr. Fillebrown on 4 October and to Mr. von Ancken on 5 October, the following information was provided by Mr. von Ancken:

a. Currently the ASR-7 (#40323) course is conducted by the Academy at a Dallas, Texas, facility. The cost data identified to conduct this training includes rental costs for classroom and office space and per diem and travel costs for course instructors.

1) Costs

a) $10,775 for 16 student class for 200 hours
b) per student week cost = $134.68

b. The Solid State Video Mapper (#40328) course is conducted at the Academy. The cost data for conduct of training do not include the cost factors identified above for the ASR-7.

1) Costs

a) $1,997 for 12 student class for 80 hours
b) per student week cost = $83.21

c. In reference to data requested under 1-c of my memo of 4 October, Mr. von Ancken reported that such a situation has not occurred and consequently there is no cost data.

P.J. Butler
Research Scientist

PJB/pe

Table B-1

Resident Training Cost Per Student Week

The following is the reimbursable cost of the courses being evaluated by HumRRO:

Course Number & Title		Cost per Student Week
40200	TACAN Principles	$46.50
40216	Wilcox MARK I ILS	$99.83
40318	ATCBI-3 TX IND	$84.75
43411	NAS I/O Equip. for Tech.	$65.16
43413	IBM-9020 CCC	$75.81
40115	Solid State Fundamentals for EM	$98.50
40104	Diesel Engine Generator	$90.00
40210	VHF/UHF DF	$80.50
40001	Communications Equipment	$76.36*

**This course has been replaced by Course 40007 and the cost is $63.62.*

NOTE: Reimbursable cost for Course 42002, ARTS III for Technicians, is not available at the present time.

Submitted by

OUT-OF-AGENCY TRAINING INFORMATION

GENERAL: The out-of-agency training program is required to fulfill several training needs that cannot be reasonably met within the FAA centralized training program. Examples of these are new systems that must be taught by the manufacturers of the equipment, and minor specialized training where requirements are very small. Use is fully made of free customer training or other government training (often free), leaving the Academy the responsibility of meeting large and standard training needs. Only a few training areas exist where Academy and Out-of-Agency have similar topical coverage and even these are not identical.

The degree of success in each out-of-agency training course depends on many factors that are not completely within the control of the FAA. These include maintenance philosophy, prerequisites, system approach, application and level of training, etc. Even so, evaluations of out-of-agency training have generally shown a fairly high degree of success when fully coordinated and is a versatile training tool.

The cost of each out-of-agency training course depends on many factors; some are:

1. Computer/non-computer type of training.
2. The number of students per class; total students.
3. Urgency of meeting training needs quickly on new equipment.
4. Course development costs, if required.

COST INFORMATION: In addition to the data supplied in Table B-1, the following comments should be noted:

1. This data pertains to FY-71 contract training and does not include training provided at no cost (i.e., approximately 1800 student weeks).
2. Preparation costs are sometimes identified (but not always) in a contract for training.
3. Notes shown at end of table explain general category of training or priority.

Table B-2

ANF OUT-OF-AGENCY TRAINING

Course	Contractor	Students/ Class	No. of Classes	Total Students	Prepara- tion Cost	Cost/ Class	Class Length	Cost/Stu- dent week	Note
RBDE-6	Westinghouse	20	6	120	$20,642	$ 4,994	2 wks	$ 124.85	1
SSVM	Texas Instruments	12	4	48	9,000	8,000	2 wks	333.33	4
1240 Magnetic Tape	UNIVAC	2	1	2	0	5,315	3 wks	885.83	4
FR-1800 H Recorder	AMPEX	10	5	50	0	2,650	7 days	265.00	1
ASR-7 (Engineers)	Texas Instruments	6	1	6	0	8,115	2 wks	676.25	4
ASR-7 (Instructors)	Texas Instruments	6	1	6	0	12,700	3 wks	705.55	4
1219 Computer Maint.	UNIVAC	2	1	2	0	4,800	2 wks	1200.00	3
TPX-42	Airborne Instruments Lab	10	4	40	0	17,913	6 wks	298.55	1
Maint. Seminar	Multi-Amp	varies	5	12	0	175	1 wk	170.00	2
Coordination Seminar	Multi-Amp	varies	6	6	0		1 wk	275.00	2
VOR (Wilcox)	Wilcox	11	1	11	0	2,000	1 wk	181.81	3
Rotating Beam Ceilometer	Weather Bureau	9	1	9	0	1,582	1 wk	176.88	3
ARTS-III Tech. Theory	UNIVAC	20	4	80	76,247	15,001	11 wks	70.00	4
ARTS-III Tech. HOT	UNIVAC	12	7	84	In above	4,345	6 wks	60.00	4
ARTS-III Tech. Supvrs.	UNIVAC	16	3	48	80,000	21,000	6 wks	219.00	4
ARTS-III Hi-Speed Equipment	UNIVAC	10	2	20	0	28,600	10 wks	286.00	4
AVERAGES		10.4	3.2	54.4	N/A	8,592	3.6 wk	370.81	

NOTES:
1. New equipment, no Academy training planned for future.
2. Industrial training.
3. Small requirement, special training, Academy training not planned.
4. Initial training new equipment, urgent requirement.

2 August 1971

MEMORANDUM

FAA Technician Career Progression Patterns

Note: (This memorandum sets forth an understanding of the FAA Technician Career Progression Patterns resulting from an interview with Mr. Max Robinson, Acting Chief, Manpower Training and Budget Branch, SM-230, on 30 July 1971.)

A. Individual Career Management

There is no formal documentation available which describes FAA Technician Career Progression Patterns from one career field to another. Handbook #3000.10, "Airway Facilities Maintenance Technical Training Handbook" dated 11/12/68, indicates the training progression by career fields. The training progression charts indicate the sequence of training experiences required as a function of the ultimate training goal in terms of specific equipments to be maintained and specific courses to be undertaken. Career progression, as such, implies not only the accomplishment of specific training but also assignment and accomplishment of specific work and the potential movement of personnel from one career field to another.

Management of FAA technician personnel is a decentralized one. The 11 regions operate within broad guidelines, but there is no attempt made at the Washington level to control or manage careers of individual technicians over the long haul of their careers. All new hires must be selected from a Civil Service roster. The only exception to this is in those cases where the individual had once been a Civil Service employee. The individual must also be within reach on the roster. That is, his name must appear within the first set of names on the roster--for example, 5. A new hire is obtained to fill a specific job position, which position is generally at some FAA facility, sector, or what have you. The notice of the availability of the job opening or a vacancy announcement is advertised in house. The extent to which knowledge of the availability of a vacancy is made known varies from a small area to the whole agency. The selection of the new hire is made by a group of people who review the qualifications of a set of applicants.

Since each new hire is to perform the work required at a particular installation or facility, any subsequent training which he may be exposed

to will be quite directly related to the requirements of the job he is to perform. As a consequence, there is no common initial training experience which all new hires are subjected to in a technical training sense. The specific training program a new hire will attend will be determined by his supervisor on the basis of an evaluation of his background and the requirements of the job which he will be expected to do.

When position vacancy announcements are made technicians can bid on them. The bid essentially is an announcement on the part of the technician that he would like to be considered for that job. There is nothing to preclude technician from moving from one career field to another. A technician having been selected for a particular job might have accepted that job because it was available and offered to him, although, in fact, his principal interests might lie in a different career field area. Thus, when an opportunity arises for a job in a different career field he takes the opportunity to bid on the new job. In addition, since the jobs are specific to particular facilities, it may often happen that the location of the new job is at a geographical place viewed to be more satisfactory to the job applicant than the place where he is currently working. Thirdly, the job vacancy may be essentially a promotion, in which case his application for this new job may be in an attempt to get a promotion. Thus there are three reasons, at least, for individuals moving from one career field to another; at the location of the job, promotion potential and changes of interest.

At present the data processing or automation career field is the only one with a positive management position. Management is attempting to obtain personnel to fill automation job vacancies who not only will be able to understand the maintenance requirements and perform them, but also to understand agency functions and how they fit into the program. With respect to filling automation vacancies the in house job vacancy announcements routine is taken. One of the advantages of taking people from within the agency to fill automation vacancies is that agency personnel are in a position better to evaluate performance and attitudes of such people since they have been employees for some period.

There are some jobs which are viewed by the technicians as dead-end jobs. One such in the data processing field is that of the I/O Technician. The central computer complex has a senior job position entitled Crew Supervisor. There are two subordinate job positions of equal rating--the CCC Technician and the I/O Technician. Supervisors are frequently selected from the CCC Technician slot rather than from the I/O Technician slot. As a consequence, personnel in the I/O Technician slot move to the CCC Technician slot, when they can, in order to be able to advance to the Crew Supervisor slot when that position becomes vacant.

Headquarters maintains no records on individual technicians in terms of their training and work experience for career management purpose.

MEMORANDUM

FAA Technician Career Progression Patterns

It would appear that the individual technician enjoys the freedom to plan and manage his own career program, the only limitation to it being the occurrence of opportunities in the direction of his interest as they appear from time to time in various vacancy announcements and his own qualifications. With the exception of the automation and data processing area there appears to be little or no emphasis on the part of headquarters to influence personnel movement through the system.

In summary, the following points can be made about career progression management in the FAA:

1. There is no overt plan or overall program, managed at the headquarters level, to guide the individual maintenance technician's career from point of entry into the agency through a variety of training programs and job assignments, from one career field to another to his retirement.

2. Job changes by practicing technicians come about essentially through individual initiative; i.e. the technician seeks a change for one reason or another and takes the action to acquire the change.

3. If any control or guidance of the individual's career through FAA technician ranks is attempted, it is done so at the local level.

4. Supervisors determine the training needs of their technicians using published agency documents for guidelines.

B. Training Requirements Projection

A planning document, generated to assist in making manpower and training decisions, is the five-year plan. This plan includes the projected current fiscal year requirements. It also projects the requirements for the next year for budget purposes. For succeeding years it provides estimates of what the requirements will be. Among the sources of information used in making these projections are the existing training programs, and secondly, the requirements imposed by the acquisition of new equipment. These plans take into account the probable attrition to be found in the system. Attrition factors include losses due to resignations and deaths, and, in addition, movement from one career field to another. At the present time, as noted above, the agency is seeking to fill vacancies in the data processing automation field from within the system. If a man is currently working in the Radar field, for example, and is accepted in the data processing field, it automatically creates a vacancy in the Radar field which then impacts upon the training requirements in that field. Training requirements imposed upon the system as a result of personnel moving from other career fields into the automation field has been termed back-fill training.

Once the training requirements have been projected these requirements are announced to the academy which then takes necessary action to

implement the plan including distribution of quotas to regions which, in turn, break out the quotas to sector level.

When classes are convened for a particular course the students taking training will have arrived there on the basis of assigned quotas. In general, no more than the maximum number of students as assigned by the quota will undertake training. There are, however, occasions when fewer than the maximum number of students will appear for training. This comes about because a student who had been previously identified as assigned to that class will no longer be available for training at that time, and there would be insufficient time to provide a substitute and the quota will go unutilized. There are, in addition, less common situations where an urgent requirement to train an individual is identified after the quota has been filled and special arrangements are made to permit the course to be conducted with a larger number of trainees than originally planned for.

In the past, under-subscription of the quotas seemed to have been a problem. It is no longer so the case.

INSTRUCTOR BACKGROUND

Name ______________________ Section __________ Date __________

Age __________ Present GS Grade and Series ______________________

FORMAL EDUCATION:

A. Total formal education high school and college

11 12 13 14 15 16 17 or mor

(Circle one)

B. If you have a degree, identify major ______________________

Name of degree ______________________

Degree granted from ______________________

TECHNICAL TRAINING:

List all technical training you have received in trade schools, military, or the FAA.

Subject	Approximate Length	Training Conducted By

INSTRUCTOR TRAINING:

List all courses whose purpose was to prepare you and/or improve your skills as an instructor.

Course Title	Approximate Length	Administered By

MAINTENANCE EXPERIENCE:

A. General - The categories listed should not be specific; for example, electronic, electrical, mechanical, air conditioning, etc.

Type of Maintenance	Length	For Whom

B. Specific - List in months actual experience in maintaining equipment you are currently teaching at the Academy.

INSTRUCTOR EXPERIENCE:

A. General - List all teaching experience you have had.

Subject Taught	Length	For Whom

B. Specific - Give the months of experience teaching in your current job ____________. What is the subject you are now teaching? ______________________________________